NOVA IMS Information Management School

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Mestrado em Gestão de Informação
Master Program in Information Management

A FRAMEWORK FOR DASHBOARDING CITY PERFORMANCE

An application to Cascais smart city

Guiomar Correia de Matos de Andrade Fernandes

Project Work presented as partial requirement for obtaining the Master's degree in Information Management

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Advisor: Professor Doutor Miguel de Castro Neto

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ABSTRACT

There has been a recent move to open up the data about the cities and transform it in indicators of interest to share with citizens through online, interactive data visualizations, often termed 'city dashboards'.

This project reflects on the building of dashboards mainly based on open data generated in the smart city context of Cascais.

The main goal of these dashboards is to provide detailed information about city performance and trends, without citizens or the managers of the municipality needing to collect or learn how to handle data. These open data and dashboard initiatives are changing not only the relationship between government and the public, but also the way that the municipality is managed.

The work begins with a literature review composed by a framework describing the characteristics of a smart city followed by an approach about the open data and a perspective about dashboards.

Then, a benchmarking is presented as a means to select a series of indicators that can efficiently capture the performance of the smart city. These indicators will feed the dashboards that will permit to see Cascais as visualized facts, changing the way how managers and citizens know their municipality.

The work also identifies the need of a graphic rules manual to follow up in future dashboards in order to achieve coherence in the public share of dashboards by the various departments of Cascais.

The project ends with the presentation of a set of key indicators that describe the municipality in several dimensions and with an application case of the constructed dashboards to the open data portal of Cascais.

KEYWORDS

Dashboard; Smart City; Open Data; Benchmarking; Cascais

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LIST OF ABBREVIATIONS AND ACRONYMS

BI Business Intelligence

CO_2 Carbon Dioxide

ETP-Process Extract, Transform and Publish Process. The process that starts with (raw) data in a database and ends with a publishable, published data set

EU European Union

GDP Gross Domestic Product

ICT Information and Communication Technologies

KPI Key Performance Indicator

Mockup Prototype of the dashboard, dashboard sketch

NO_2 Nitrogen Dioxide

O_3 Ozone

PM_{10}, $PM_{2.5}$ Air mass suspended particules, related to traffic emissions

SC Smart City

1. INTRODUCTION

The urban population in 2014 accounted for 54% of the total global population, up from 34% in 1960, and continues to grow. It is estimated that in this year 2017, even in less developed countries, a majority of people will be living in urban areas (World Health Organization, 2014). As the planet becomes more urban, cities need to become smarter. Major urbanization requires new and innovative ways to manage the complexity of urban living (Rizzo, Deserti & Cobanli, 2015).

Thus, a new management proposal arises: more integrated, more sustainable and more efficient. The core of the management is no longer so focused on the physical ability to live in cities, but focused on the citizens and on the increasing of its livability (Directorate-General for Territorial Development, 2015a).

It is in this context of transforming the infrastructures and systems of the city into optimized results that the concept of smart city arises. Cities that are based on intelligent approaches to the various sectors and focus on providing effective responses to the needs of those who inhabit them: the present and the future citizens (UK Department for Business Innovation & Skills, 2013).

Since citizens are their core, the smart cities should be transparent to them. To this end, smart cities should allow the exchange of data and information with their citizens (Smart Cities Council, 2014). In the smart cities' vision, the generation and analysis of contextual and actionable data is a central pillar, with the city becoming increasingly knowable and controllable in new dynamic ways (Kitchin, Maalsen & McArdle, 2015). However, it was considered in this work that, the value of the data stored by the smart city is only tangible if shared with the various stakeholders that are part of it (like citizens, governors, tourists and investors, for example).

The data should be shared for understanding, monitoring and planning the city (Kitchin, 2014). It is for this purpose that dashboards were built on this project. Their aim is to transform the city data into information and knowledge by showing the performance of Cascais: a municipality managed according to a smart city strategy. The main goal is to make this project into the transition link between the raw data and the information by creating the framework between the data that nothing transmits (due to its initial and raw state) to the citizen and the information with useful purposes.

Initially, this project was intended to only use open data feeding the dashboards. However, other sources of data emerged due to two reasons. The first one was the fact that the open data portal of Cascais is still in its initial state, not allowing the existence of sufficient open data to feed the indicators of interest. The second reason is the fact that the benchmarking was the way outlined to achieve the initial choice of indicators. The constituent cities of benchmarking have different characteristics of the municipality under study and, as expected, there is no open data available on the portal for all key indicators resulting from the benchmarking.

The need of other sources to construct the dashboards was accepted because, despite the importance of the open data in Cascais, the objective is to find out the best way to monitor the performance in order to improve the quality of life of the citizens, to inform and alert governors and to transmit knowledge about the city.

The research question goes through discover the best way to show the performance data of the city always with the aim that, with the release of these data, the quality of life of the citizen improves. This may occur due to a large number of factors like the following examples:

- The citizens are more informed and therefore can make better decisions based on facts;
- Organizations can create new innovative solutions whose need for existence has been verified through the analysis of the released data;
- Municipal managers can find flaws and potential opportunities to improve the municipality, track the progress of services and identify needs of citizens.

1.1. CONTEXTUALIZATION

This project is developed in Cascais, a municipality that benefits from a mild climate, with an extensive coastline (30 Kilometers) with more than fifteen beaches and natural landscapes (that occupy a third of its territory) and near the capital (Lisbon). With 97.4 km² of area and with approximately 206 479 inhabitants (Statistics Portugal, 2011),it is the 6th most populous urban area of Portugal.

It is a modern municipality that is concerned with the development of contemporary approaches to manage and plane the future of the community. For this purpose it uses a smart city strategy. For such, the efficient and intelligent use of technology is essential and, like any smart city, Cascais will achieve positively it goals only if it has the feedback and collaboration of its inhabitants. Therefore, the constant connection with the inhabitants is fundamental to the use of their information as a means of achieving efficiency (UK Department for Business Innovation & Skills, 2013).

In order to achieve assertive collaboration from the citizens, transparency in the communication of strategies and results is essential. To gain this governmental transparency it is necessary to analyze and transmit the data generated. To reach an efficient communication, the sharing of data and information using definitions and standards that any user can use, reuse and interpret is essential. It is a process that makes the data and the citizens smarter (Manville et al., 2014).

Following the principles of smart city, Cascais has been producing a large number of data (through the information technologies present in the various dimensions of the municipality) that can support the planning and the management of the municipality and improve the knowledge about the territory and about the inhabitants. Therefore, it is necessary to develop a framework to release this data.

The data to be transmitted is mostly open data, so it can be used by anyone for any purpose. It must be easily accessible, usable and reusable. This kind of data that will be transmitted enables: more efficient and effective governance (through the identification of new ways of improving the provision of public services and ways of adjusting to citizens' needs through digital technologies) and transparency (allowing citizens and civil society to see, understand and better monitor what their government and the private sector are doing)(Davies, 2013).

1.2. STUDY GOALS

The main objective of this project is the construction of city performance dashboards for the municipality of Cascais mostly supported by open data.

The dashboards should make the data useful and easily interpretable by any dimension of the smart city, allowing the assimilation of information without the need of work the raw data.

The dashboards should cover the economic dimension, the social dimension and the environmental dimension of the data. Such choice is based on the fact that smart cities are sustainable cities and the three pillars of sustainability are the economic, social and environmental, according to the conclusions of the United Nations 2005 World Summit on Social Development.

The monitoring of information about these dimensions will be used as a mean to support the analysis of this data, thus generating insights on how to improve the performance of the smart city in the service and citizen's quality of life.

In order to achieve this, the following steps must be carried out in advance:

- Conduct an international benchmarking in how other cities measure and present the three dimensions of interest (economic, social and environmental);
- Study best practices for visualizing the performance measures using dashboards;
- Select which indicators best describe the level of performance of a smart city on these three dimensions;
- Select required data sources and prepare data;
- Characterize the dashboard design template;
- Built the dashboard and analyze the results obtained.

1.3. RELEVANCE OF THE STUDY

According to the Smart Cities Council (2014), the three core functionalities of smart cities are to gather data (measure and monitor the current conditions), communicate the data and analyze it. The objective of this project is focused on the communication part since the main objective of the project is to monitor the large amount of data already generated and gathered, summarize it and make it easily viewable by any individual.

Due to its many technologies, like sensoring, a smart city is a big data generator (Kitchin, 2014). Because this data is so voluminous, these dashboards arise as a need to visualize, understand, explore and communicate information, not data.

For a smart city to be successful it has to have an open access and open data approach that enables their citizens to access the information they need, when they need it (De Marco, Mangano, & Zenezini, 2015). The dashboards developed will grant any citizen the access to transparent outcomes allowing them to compare the performance of the city.

The dashboards will also allow the municipality itself to have a clear view of its characteristics and to identify what changes need to be made in order to create more attractive environments and better quality of life.

With the creation of these dashboards it is expected the improvement of the public services. It is important for citizens to become smarter, with the intention of acting and thus be more integrated in the services of their city.

In addition to the demonstration of key indicators that represent the performance of the city, this project also has the objective to serve as guideline to other cities that want to implement a similar solution to monitor their data. Although the indicators presented are adapted to the characteristics of the municipality under study, it is intended that the followed processes can be easily adapted to other cases.

1.4. METHODOLOGY

The chosen methodology to follow on this project was the "Design and Creation Research" proposed by Oates (2005). It is a cycling process that focuses on the development of IT artifacts and on the creation of missing knowledge. On this case, the artifacts will be the developed dashboards. Is a design process characterized by learning via making and the five major steps are:

1. Awareness: the recognition and articulation of a problem.
   The recognition came from the need for visualizing the data produced by the smart city. This visualization will be useful both for the inhabitants (to have government transparency) and to management of the city (allowing the identification of possible problems or opportunities). The articulation of the problem will be characterized by an extensive review of the literature that will help to plan and define the dashboard components, the open data concept, features of a smart city and indicators to evaluate its performance.

2. Suggestion: tentative idea of how the problem might be addressed.
   Is the creative step to envision of a new functional artifact and the expected output of this step is a tentative design. On this case, the output expected will be the first mockups with the first experimental metrics. The choice of the first metrics will be based on a benchmarking that should have, as output, the best indicators to capture the performance of a city.

3. Development: is the implementation of the tentative design and the expected output are the artifacts: the dashboards built using Power BI (a Microsoft tool created to monitor and analyze data along the organizations). On the development, an integration of the data that will feed the dashboard must be carried on. For such, an assessment must be made to verify which open data has already been published and what data is need to properly characterize the smart city.

4. Evaluation: leads to new awareness (iterative) or to conclusion once the completion of the previous phases presupposes a reassessment. It is a built and

evaluates methodology which means that, after produce and apply knowledge to create effective artifacts that should solve a problem, it is necessary to analyze the use and the performance of artifacts. The question that will determine the efficiency of the performance of artifacts will be: the used indicators characterized the performance of the smart city?

5. Conclusion: the results of the research and determination why and how the artifact worked or did not work.

It cannot be ignored that the process of analyzing data is not static nor does it have an end. All the above phases are interlinked and should be reviewed when new updates are available. It is a continuous cycle and even after the results have been published, measures should be taken to ensure accuracy, meaning and timeliness of data (Carrara, Oudkerk, Steenbergen, & Tinholt, 2016).

The investigation process considered for this work is composed by five stages and is presented on Figure 1.1.

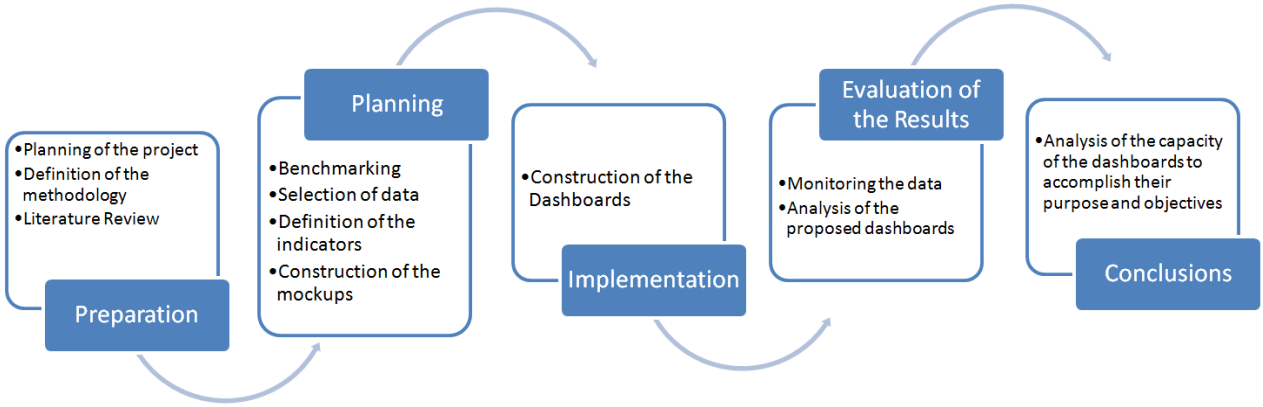

Figure 1.1 - Investigation process used on the project

2. LITERATURE REVIEW

On the present chapter, it will be presented a literature review that served as theoretical basis to the development of this project. The chapter begins with a brief description about the definition of Business Intelligence, followed by an approach to some proposed definitions and model of smart city. The section ends with some insights about the incidence of smart cities internationally.

This chapter also contains the characteristics and objectives of the open data as well its process followed by the presentation of the open data portal existing in Cascais: the Cascais Data.

At the end of the chapter is presented the theme of dashboards with the related correct practices during the construction.

2.1. BUSINESS INTELLIGENCE FOR CITIES

The business pressures resulted of today's competitive climate leaded us to an evolution of decision support concepts overtime. To organizations excel on this turbulent environment (solving problems and exploiting opportunities) is always present a need for computerized support of managerial decision making (Varghese & Ramakrishnan, 1991).

The term Business Intelligence emerged amongst main objective of closing the gap between the current performance and the desire performance. According to Watson (2009), BI is a broad category of applications, technologies and processes for gathering, storing, accessing and analyzing data to help business users make better decisions. The objectives are to enable everyone throughout an organization to quickly and easily access any data, possibly in real time, as well as conduct appropriate manipulation and analysis. BI helps transform data to information, to knowledge, to decisions and finally to action (Negash, 2004). In the smart cities context, the BI term follows the referred characteristics but acts more linked to the urban analytics. Urban analytics is also a set of tools, methods and processes oriented to the processing and analysis of a set of data with urban information of the diverse areas associated to the smart cities. Aligned with the BI objectives, the main goal of urban analytics is to support decision-making (Directorate-General for Territorial Development, 2015b).

This project will be focused on the component of BI that provides a comprehensive view of performance measures and trends, once it will be develop a dashboard in a smart city context. On the next point we will define the definition, context and framework the smart city topic.

2.2. SMART CITY

Although the term has been gaining more popularity since the last two decades, define what is a smart city is still an ambiguous task. The label "smart city" is a fuzzy concept and is used in ways that are not always consistent. There is neither a single template of framing smart city nor a one-size-fits-all definition (Albino, Berardi, & Dangelico, 2015). To have a general idea of an example of a possible definition is proposed a table (Table 2.1) that reports some of the different meanings given to the concept by some authors.

Definition	Source
Smart city as a high-tech intensive and advanced city that connects people, information and city elements using new technologies in order to create a sustainable, greener city, competitive and innovative commerce, and an increased life quality.	Bakıcı et al. (2012)
A smart city is based on intelligent exchanges of information that flow between its many different subsystems. This flow of information is analyzed and translated into citizen and commercial services. The city will act on this information flow to make its wider ecosystem more resource efficient and sustainable. The information exchange is based on a smart governance operating framework designed to make cities sustainable.	Gartner (2011)
Smart city generally refers to the search and identification of intelligent solutions which allow modern cities to enhance the quality of the services provided to aware citizens.	Giffinger et al. (2007)
Smart Cities initiatives try to improve urban performance by using data, information and information technologies (IT) to provide more efficient services to citizens, to monitor and optimize existing infrastructure, to increase collaboration among different economic actors, and to encourage innovative business models in both the private and public sectors.	Marsal-Llacuna et al. (2014)
The idea of a smart city is rooted in the creation and connection of human capital, social capital and information and communication technology (ICT) infrastructure in order to generate greater and more sustainable economic development and better quality of life.	Manville et al. (2014)
Cities [should be seen as] systems of systems, and that there are emerging opportunities to introduce digital nervous systems, intelligent responsiveness, and optimization at every level of system integration.	MIT (2013)

Table 2.1 - Adapted table with the smart city definitions proposed in studies by Albino, Berardi & Dangelico (2015) and Manville et al. (2014)

2.2.1. The Smart City Model

Various models for understanding and conceptualizing smart cities have been developed, which aim to define their architecture. The main question is that many authors support their scopes on governance, others on services, environment or facilities, for example. With the objective of unifying and reach a consensus, in 2016, Anthopoulos, Janssen & Weerakkody carried out a study where the various models already proposed were analyzed. The result was a unified smart city model that is composed by six dimensions that are recognized an agreed by all scholars, even with small variations.

The six axes that the smart cities have been further defined are:

- Smart Economy
- Smart Mobility
- Smart Environment
- Smart People
- Smart Living
- Smart Governance

(It is possible to overview the six smart city axes in Table 8.1)

Based on the referred dimensions and in the model proposed by Khatoun & Zeadally (2016) the following model is suggested which places the citizen as the center of all the axes once they exist to meet their needs (see Figure 2.1).

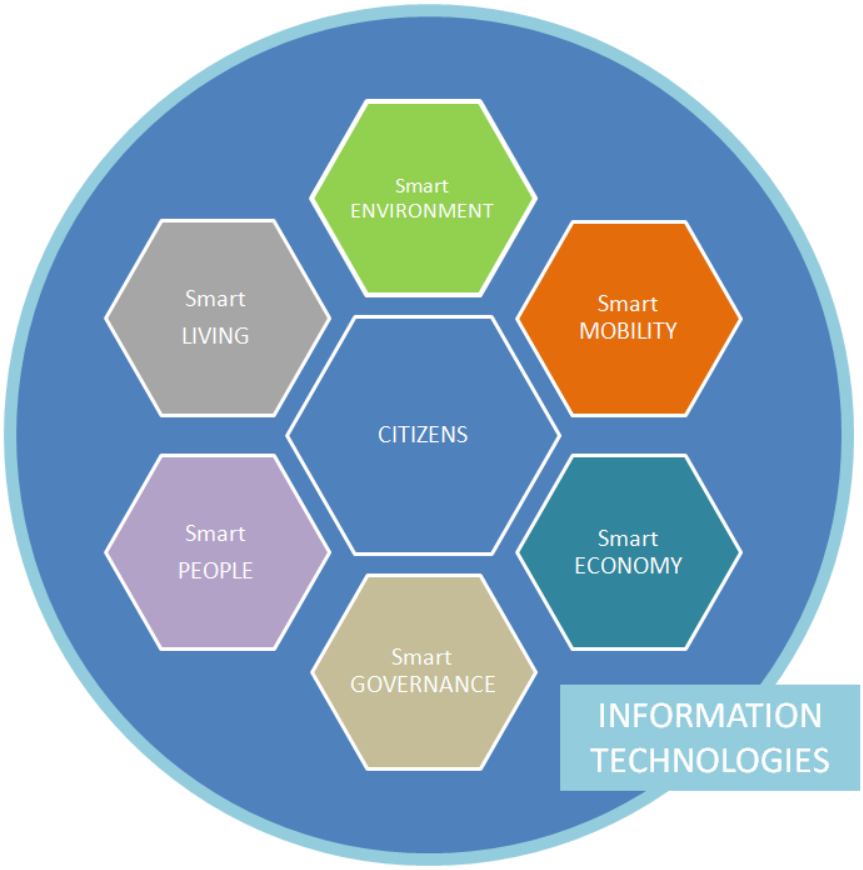

Figure 2.1 - Proposed model for smart cities adapted from the proposed by Khatoun & Zeadally (2016)

All these six dimensions are framed on the three pillars of sustainability already mentioned. Each dimension has its own contribution to each of the three pillars. As the International Electrotechnical

Commission (n.d.) affirms, all the models and architectures defined by the various authors have in common the basis of the three pillars.

Following the work proposed in "New Key Performance Indicators for a Smart Sustainable City" (Hara, Nagao, Hannoe, & Nakamura, 2016), on this project it will be constructed a dashboard per pillar of sustainability: social, economy and environment. Each pillar encompasses the six referred dimensions with different weights, so the defined model for a smart city will be respected.

On the Figure 2.2 it is possible to have an empirical overview of the weight of each dimension on each pillar of sustainability considered on this project, according the potential impact of local politics priorities/projects.

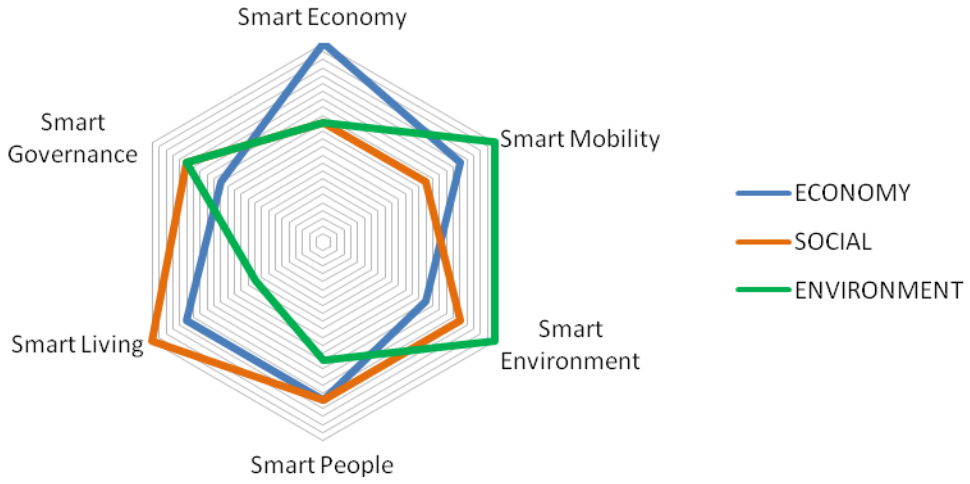

Figure 2.2 - Weighting of each dimension in the sustainability pillars

2.2.2. Smart Cities Worldwide

To complete the contextualization of the concept, it is considered important to have some general ideas about how smart cities are performing globally.

As will be explored later, there are a several number of indexes attempting to measure and classify smart cities. It is an ambiguous task to classify the best smart city but, in an attempt to reach a consensus, it is possible to affirm that the cities whose references most appear in the top of divers indexes and rankings are New York (USA), London (UK), Paris (France), Boston (USA) or Tokyo (Japan) for example, as it is possible to examine on two of the manifold indexes Global Cities 2016 (A.T. Kearney, 2016) and IESE Cities in Motion (IESE Business School & Center for Globalization and Strategy, 2016).

Since Cascais is located in Europe, this section will be concluded with brief key findings in how European cities are performing along the six dimensions previously referred. The key findings refers to a study conducted by Manville et al. (2014) based on a database of all 468 cities with a population of at least 100 000 citizens within the 28 Member States of the EU.

After the collection of the data about these 468 cities, the authors decide that the threshold for being considered on the study a smart city is to have at least one of the six characteristics. For that, they examined elements such strategies, projects, platforms, networks and programs and identified 240 of the 468 that are considered smart cities. Some conclusions are:

- There are more small smart cities than large ones, but there are smart cities in all size categories and in most EU-28 countries.
- The incidence of smart cities decreases with city size. This does not mean, however, that smaller cities are not engaging in smart city development as it's possible to see on Figure 2.3;

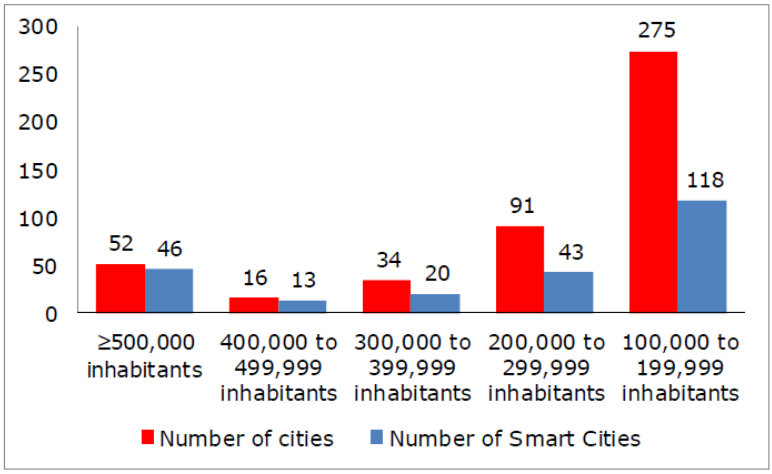

Figure 2.3 - The ratio of smart cities to cities across the EU, according to Manville et al. (2014)

- City size is clearly positively correlated with the number of characteristics sought through smart city initiatives, as Figure 2.4 demonstrates. Smart cities with only one characteristic tend to have between 100,000 and 200,000 inhabitants. This supports the notion that larger cities tend to have the greatest resources and more ambitious smart city policies;

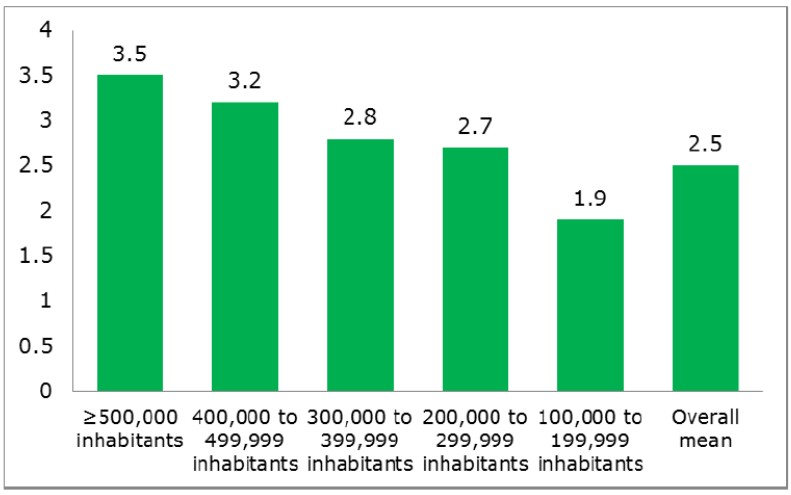

Figure 2.4 - The average number of smart city characteristics, according to Manville et al. (2014)

- Smart Environment has significantly greater representation than the other characteristics, followed by Smart Mobility. The remaining characteristics are more or less evenly distributed (around 10% coverage by all cities);
- The highest absolute number of smart cities is found in the UK, Spain and Italy; the countries with the highest proportion of smart cities are Italy, Austria, Denmark, Norway, Sweden, Estonia and Slovenia.

The majority of these conclusions are also verified for the example under study. Cascais is also a small city but is engaged with the development of solutions to become a smarter city. Following the conclusions of the study, is also in the Environment and Governance dimensions that Cascais has greater representation, like is possible to notice on the next section.

2.2.3. Cascais As Smart City

The leadership of Cascais over this theme is related to the degree of urban intelligence achieved, as result of the good practices carried out in the area of sustainability.

Cascais is one of the municipalities that has invested in new technologies in order to make the city management smarter which results in better living conditions.

Some of the technology applied to smart cities is already used in the municipality, in the daily life of the citizens who live or work there or by those who visit.

The first example is the case of the MOBI-Cascais project (https://www.mobicascais.com): an integrated transport system where, through a single application, will be possible to integrate all existing means of transport (which includes the use of shared bicycles and parking).

Another example where the innovation is present is the intelligent management of solid waste. "Smart Waste Management" (Cascais, 2015) allows, among other things, the application of sensors in the underground containers to indicate, in real time, the level of filling. Avoiding, on the one hand, that they become too full and, on the other, preventing unnecessary trips to collection. Municipal vehicles are able to do less 180,000 Kilometers per year, reducing CO_2 emissions by 352 000 tons per year, which results in savings for the municipal of 800 000 Euros per year.

But it is not only in the monitoring of containers that new technologies help. The collection vehicles are also equipped with technology that allows geo-referencing and typifying of end-of-life objects and garden cuts that are in the public highway for later management of collection routes.

Other example is the FIX Cascais (http://cascais.pt/fixcascais)application. This also allows anyone to geo-reference a situation or problem detected on the public space.

Also in the museum spaces of Cascais there is innovative technology that allows to a better management. The Museum of the Village (Cascais,n.d.) is equipped with an intelligent lighting system that adapts the luminosity of each exhibitor to the approach of the visitors, allowing the best lighting conditions in each moment.

Like the online attendance of the municipal services and the public and available information systems, there are much more other examples that put Cascais at the forefront of the smart city movement in Portugal. As well as the examples referred, this project is another initiative that goes with the goal of making Cascais smarter. It is possible to conclude that, in Cascais, the concept of smart city is very present as a means to improve quality of life.

Cascais, like the others smart cities, is a data producer. The use of this data produced is fulcrum to be considered a successful smart city. This referred use supposes the analysis of the data to constantly improve the performance of the city. The data collected by a smart city it is about its inhabitants, so it should belongs to them. For this, it must be made public and open. That is the purpose of the open data concept, explained in the following section.

2.3. OPEN DATA

Governments have a large number of basic data which can be of economic and social value to society as a whole. Along those lines, more and more European countries are developing policies to release this data as open data. Open data refers to information that can be freely used, modified, and shared by anyone for any purpose. It must be available under an open license and provided in a convenient and modifiable form that is machine readable (Carrara, Oudkerk, et al., 2016).

This data is particularly significant as a resource for increased public transparency. Open data can be used to help the public better understand what the government does and how well it performs and to hold it accountable for wrongdoing or unachieved results. In addition to increasing government transparency and public awareness of government program and activities, opening up data can also help generate insights into how to improve government performance. Additionally, data openness is eventually expected to improve the decision making of both governments and individuals (Jetzek, Avital, & Bjorn-Andersen, 2014).

In particular, the public is expected to be able to use government data to make better decision and improve the quality of their lives while governments are expected to be able to more easily access a wider range of datasets to foster evidence-based decision making (Ubaldi, 2013).

It is possible to conclude that the benefits of open data can be divided into economic, political and social indirect benefits. Economic benefits can translate into new job potential, new goods and services, knowledge economy growth, increased efficiency in public services and growth of related markets. At the political level, one can speak of increased transparency and accountability, civic participation, political awareness and access to information. From a social point of view, benefits can take the form of increased social inclusion and empowerment, civic participation, access to information and support to personal decision-making capabilities (Carrara, Chan, Fischer, & Steenbergen, 2015).

Aligned with these benefits, the Organisation for Economic Co-operation and Development (2015) ranked the top principal objectives of the open data strategy. As can be seen below in Figure 2.5, improved service delivery is the top priority.

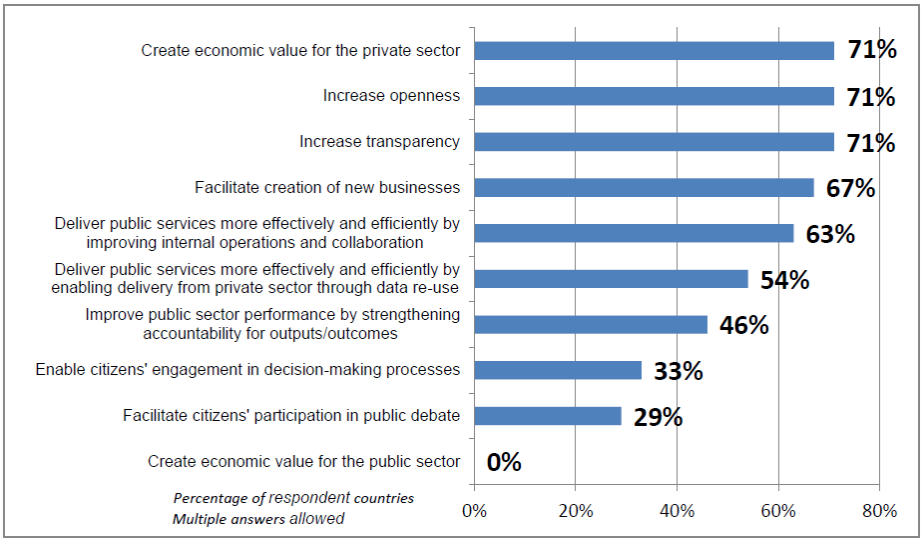

Figure 2.5 - Top 5 principal objectives of the Open Data strategy/policy (OECD, 2015)

To have some conclusions about this theme across Europe, the European Union made a research conducted by Carrara, Nieuwenhuis & Vollers (2016) about the level of maturity of the open data. For that, two key indicators were selected. The first key indicator, Open Data Readiness, assesses which countries have an open data policy in place, licensing norms, an open data policy, the open data available and the impact of open data. The second key indicator, Portal Maturity, explores the usability of the portals regarding the availability of functionalities, the overall re-usability of data such as machine readability and accessibility of data sets.

The results of this study show that the open data movement has gained acceptance in Europe on the past few years and, increasingly, European countries implement open data policies. This fact is possible to verify on the open data maturity map (Figure 2.6):

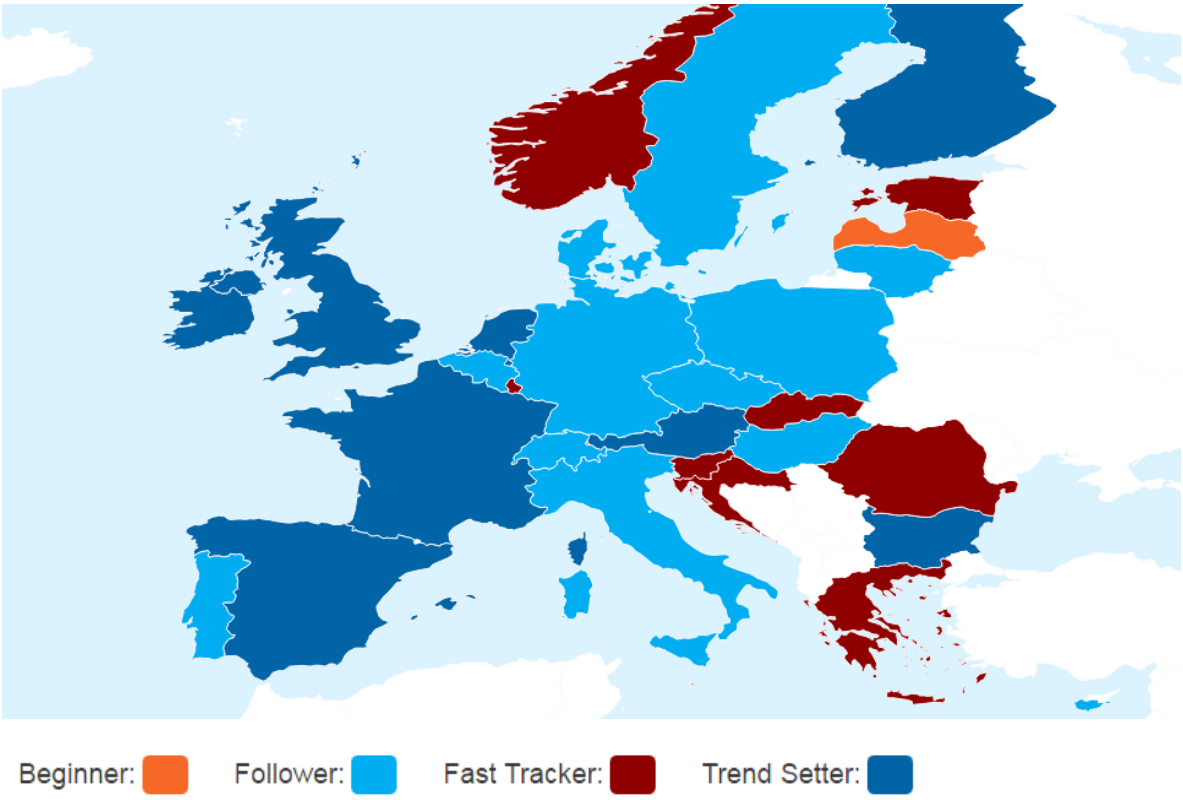

Figure 2.6 - Map with the classification of the EU countries in terms of open data maturity, retrieved from "Open Data Maturity in Europe 2016" (Carrara, Nieuwenhuis, et al., 2016)

This study also concludes that, in 2016, most countries have increased their use of open data as they have launched activities to promote their open data policies and portals. This growing attention to this subject implies an increase on the amount of public and published open data. According to Ubaldi (2013) the four main phases that can be identified in the open data creation are:

1. Data generation: this covers the generation of public data, which is normally done by public sector entities even if this function may increasingly become shared with other publicly funded data sources (e.g. social statistics, aerial data);
2. Data collection, aggregation and processing: data need to be collected, gathered to enable access, sharing and re-use. Most government data also need to be aggregated, linked, and or manipulated once open in order to add value for the majority of users (e.g. to support personal decisions). Many users would in fact not be able to understand and make use of the data as it is'. This applies in particular to non commercial re-use of government data;
3. Data distribution and delivery: data need to be distributed to the potential users to enable access and re-use;
4. Final data use: open government data need to be re-used by a whole list of different users to sustain public value creation.

To make these referred phases it is possible to rely on the traditional extract, transform and load process (ETL process) and adapt it transforming the load phase in the publish phase (Herreweghe, 2015). The ETP-Process (see Figure 2.7) is the technical specification of how data flows through the organization, transforms into a publishable data set, and eventually is made public.

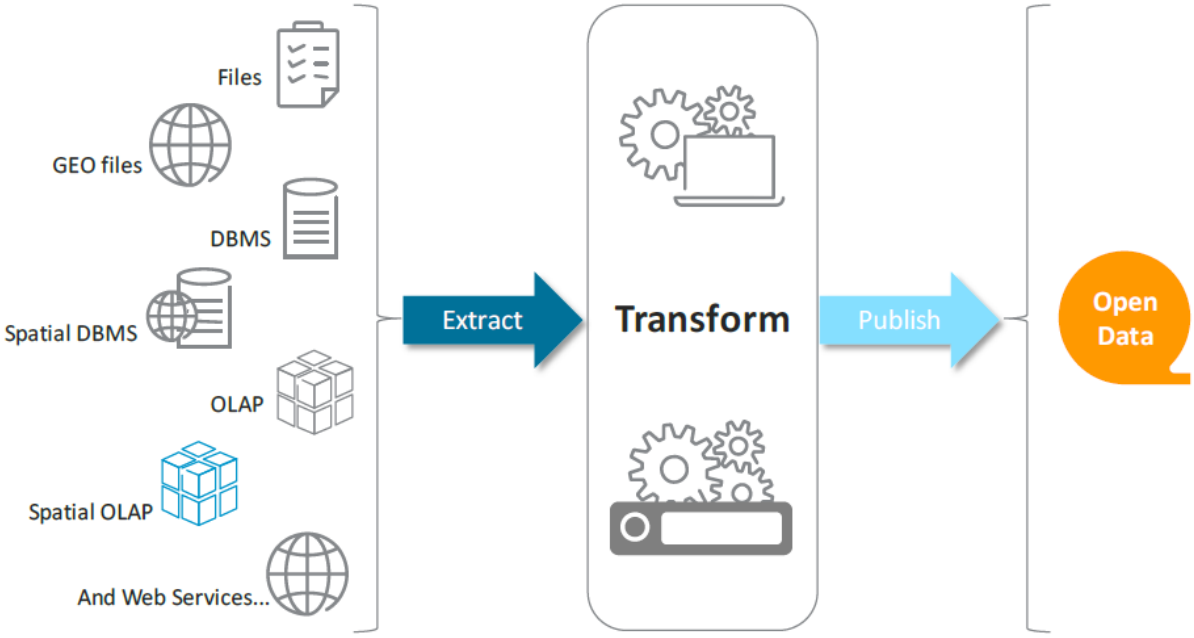

Figure 2.7 - The ETP-Proces represented in "Open Data Goldbook for Data Managers and Data Holders" (Carrara, Oudkerk, et al., 2016)

2.3.1. Cascais Data Portal

According to Catarina Selada (Cardoso, 2016), the priority area in the development of a smart city, in Portugal, is the development of an integrated strategy based on open data, available to the population. Following this principle, one of the priorities of Cascais is to make the data available to the population. Cascais has been collecting a large quantity of data that, when shared, can create value. These data, in order to reach their maximum potential, must be made public in an open data format.

Upload to a portal is the most used channel for publishing open data. As all the open data portals, the expected impact of the Cascais Data portal is to drive transparency once it bridges the gap between government and citizens in terms of information.

The Cascais Data portal will be launched soon and publishes data using CKAN (Comprehensive Knowledge Archive Network), an open source catalogue system that has become one of the major standards within Open Data portals. As CKAN is open source, it is continually improved and is available free of charge. The option to choose this catalogue system was due to its many strong features such as harvesting, publishing and auditing and has integrated data storage (CKAN, n.d.). It is possible to see in the following Figure 2.8 the general aspect of the Cascais Data.

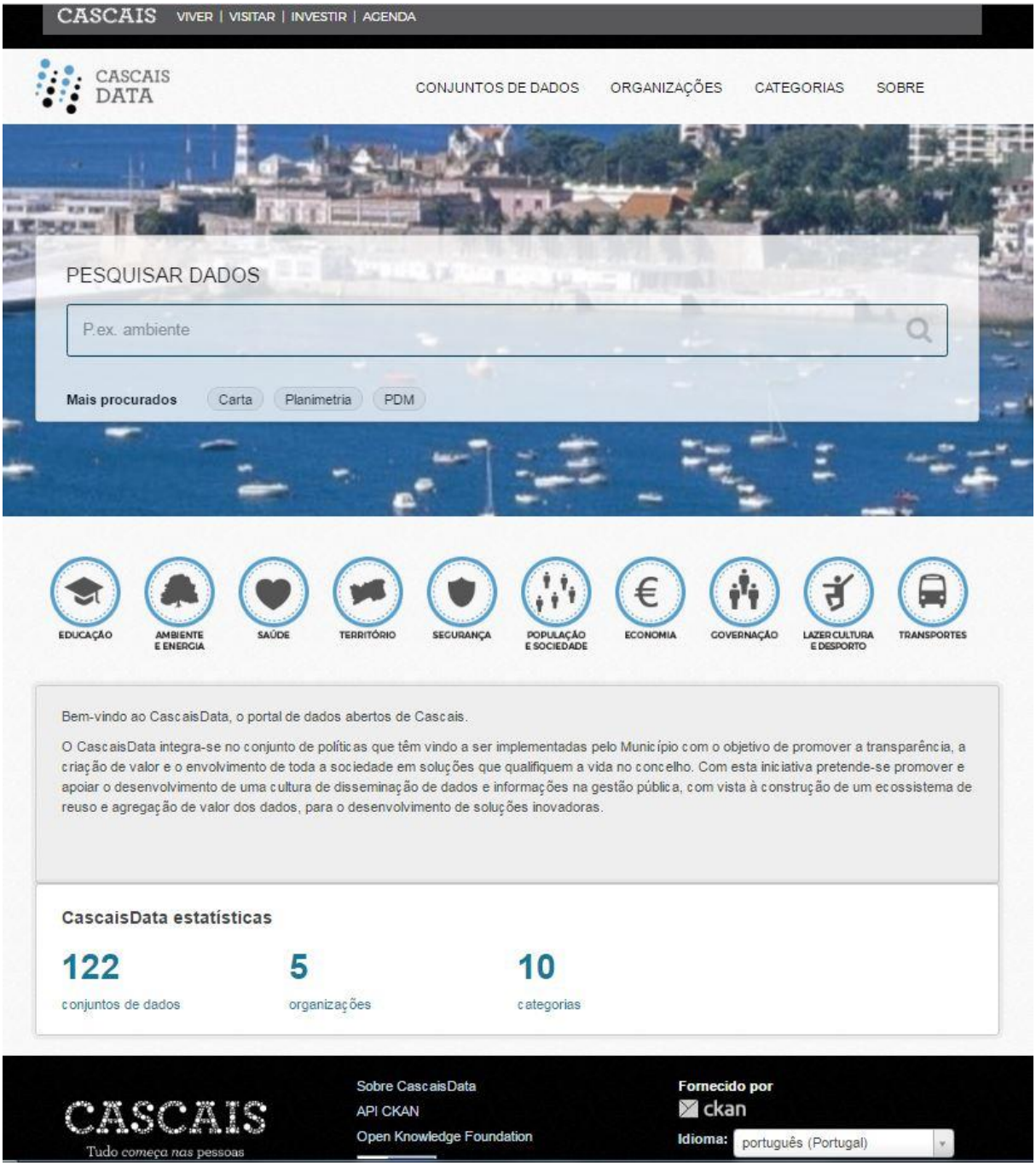

Figure 2.8 - Homepage of the Cascais Open Data Portal (the text is in Portuguese)

As it is possible to see, the Cascais Data portal is based on the ten following themes:

1. Economy
2. Education
3. Health
4. Leisure, Culture and Sports
5. Environment and Energy
6. Transportation
7. Governance

8. Security
9. Population and Citizenship
10. Territory

Align with the already mentioned open data strategy, the Cascais Open Data strategy/policy has the following three main challenges related with the liberation of the public data about the municipality:

1. Accessibility

- To have and to give access to the data produced (internal data management);
- Availability of data to be used and re-used (primary, raw, appropriate formats);

2. Quality

- Providing reliable (up-to-date, complete and consistent) data;
- Production of metadata and organization of data in order to understand it;

3. Utility

- Provision of high-value datasets according to the users interest;
- Development of an ecosystem that supports and enhances existing data;
- Monitor and document emerging impacts and benefits of open data.

To achieve the referred transparency in the communication of performance, it is necessary to transform the open data contained in the portal, and other data of interest, easily interpreted and understood by any user. For that, the city dashboards will be developed as instruments in which both public officials and the general public can interact with city data (Lee, Alvarez Felix, He, Offenhuber, & Ratti, 2015).

2.4. DASHBOARDS

On this project there will be no such focus on the ability of BI to assist business managers in their analytical and decision-making process but rather in the main objective of BI: to allow easy access to data and create a favorable environment to conduct analysis through the transformation of historical and current data, metrics and performances into three single interfaces, the dashboards.

The volume of open data produced by this smart city brings a fundamental challenge: display all the required information on a single screen clearly and without distraction in a manner that can be quickly and easily assimilated (Few, 2007). There is obviously a need for visual tools that help people understand data. It is in this context that the dashboards emerged. One example of a succinct and workable definition of a BI dashboard can be: “is a visual display of the most important information needed to achieve one or more objectives; consolidated and arranged on a single screen so the information can be monitored at a glance” (Few, 2004).

Despite being a mean to organize and interact with data, the dashboards can also be seeing as storytellers once they use their visualization tools to analyze complex data that cannot simply tell stories. They need to be ”tailored” to accommodate storytelling by better highlighting items of importance within very large data resources, in a way that is efficient for the storyteller and clear for the audience (Elias, Aufaure, & Bezerianos, 2013).

2.4.1. Data Visualization Best Practices

There are some visual considerations that can greatly improve the way that the user understands the data. Some examples are (“Guide to Dashboard Design,” 2009):

- Colors should enhance data comprehension, not distract (use fewer than six colors), the use of opposing colors should emphasize comparisons and the use of color temperatures should highlight information (cool colors to backgrounds and warm colors to data) and use the color saturation correctly (less saturation to small values and more saturation to greater values);
- Avoid combining unrelated charts into one and make sure that everything is legible;
- Consider the importance of direction (high level visualizations to the left and detail to the right and bottom);
- Avoid concentrating on style over substance and make sure that these metrics allow meaningful comparisons.

2.4.2. Rules to Dashboarding

In addition to the best practices, designing and building successful dashboards might evolve some of the following rules (“Guide to Dashboard Design,” 2009):

- Enable drill-down or drill-through to underlying data sources or reports and filters to allow flexibility and customization;
- Provide explanation and context before information;

- Require minimal training and easy to use by anyone;
- Do not exceed the boundaries of a single screen or display excessive detail;
- Use modularity to compact information and visual cues to guide attention.

The most relevant one is the selection of the right visual representation for each type of data.

One of the main tasks of this project is to choose the visualizations that better make the data meaningful and useful in order to be possible to achieve the objectives. If the visual representations are not the correct ones, the dashboard cannot be informative and useful. To help in this aspect it will be used the chart selection diagram crated by Abela (2006) and represented on Figure 2.9.

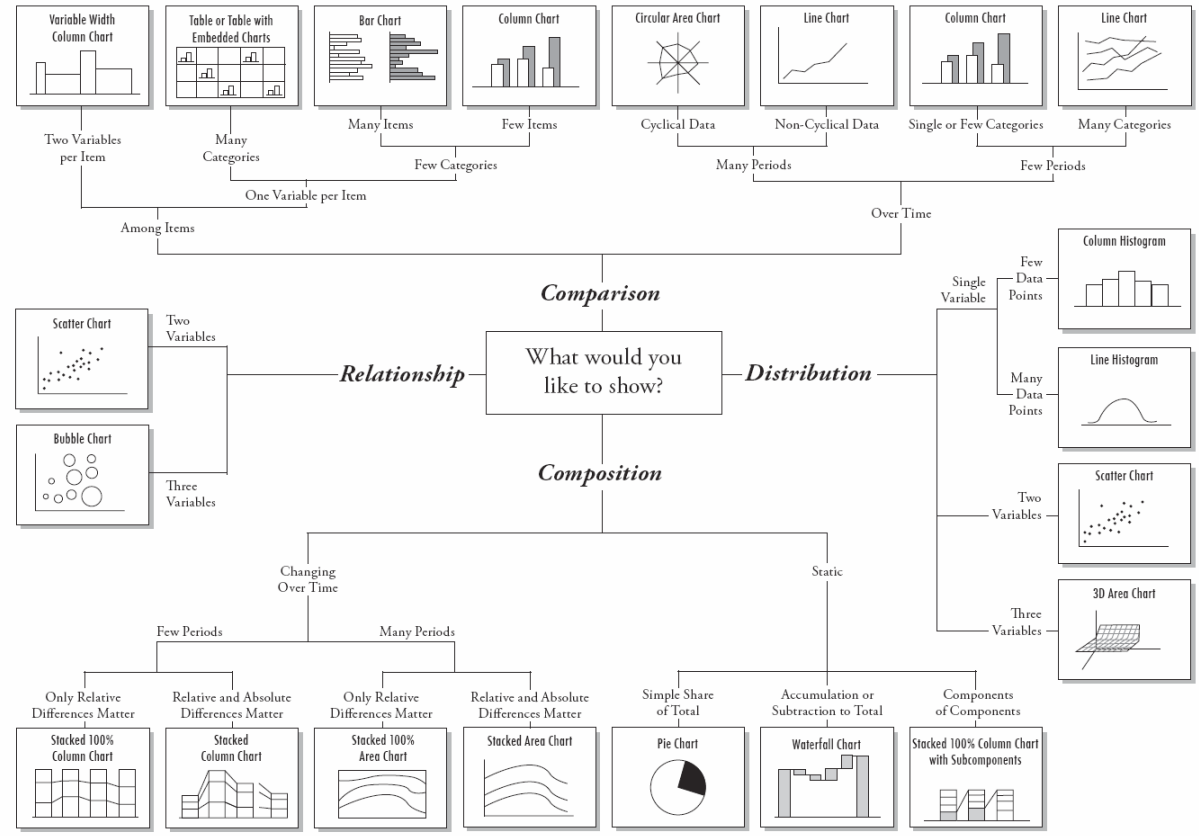

Figure 2.9 - Chart Suggestions by Abela (2009)

2.4.3. Target and Indicators

One of the most important aspects, if not the most important one, is to present, on the dashboards, indicators[1] that really matter to the audience, to the defined goals and to the problem.

The dashboards are a valuable tool to analyze data if allow to make proper decisions and if communicate performance. The selection of proper target and indicators is crucial for the effectiveness of the measurement and the data collected need to be exhaustive and representative so that the real world is described (De Marco et al., 2015).

The initial step is to define the target. If the final product has a user, it must be adapted to the characteristics of that user.

The dashboard should clearly communicate to the following potential users:

- Potential newcomers and visitors looking for information about Cascais when considering it as a place to live or to visit;
- Investors looking for strategic information about the municipality to identify potential investments;
- Inhabitants that want to be informed about their city and its performance;
- City executives and managers that want to recognize eventual lapses or possible improvements to consider.

Based on "Key Performance Indicators Related to the Use of Information and Communication Technology in Smart Sustainable Cities" (International Telecommunication Union, 2015) the selection of the indicators will be carried out using the following principles:

- Comprehensiveness: The set of indicators should cover all the aspects of the smart city and be aligned to the measured subject;

- Comparability: The indicators should be defined in a way that data can be compared scientifically between different moments, which means the indicators must be comparable over time and space;

- Availability: The indicators should be quantitative and the historic and current data should be either available or easy to collect;

- Independence: The indicators in the same dimension should be independent or almost-orthogonal i.e., overlap of the indicators should be avoided as much as possible;

[1] According to the Business Dictionary (2016), an indicator is a measurable variable used as a representation of an associated factor or quantity.

- Simplicity: The concept of each indicator should be simple and easy to understand the calculation of the associated data should be intuitive and simple;

- Timeliness: This is defined as the ability to produce indicators with respect to emerging issues in SC construction or stage or development.

The data that will feed these indicators is also a parameter of importance. Within the context of the smart city, data are used as input for decision making and to inform (citizens, city managers or other entities).

The data quality needs to be considered at all aspects of the data lifecycle and in the development and use of applications. Otherwise, the dashboard can be constructed based on data with quality issues which may result on propagation through multiple systems and lead to poor information and unreliable 'evidence-based' decisions (Mcardle & Kitchin, 2016). If the transmitted data is not reliable, when the users take evidence-based decisions with that data, the outputs of these actions will not be accurate or correct and the main purpose of this project will not be achieved.

It is then considered necessary to check the quality and veracity of the data to be used in the dashboard so it can inform users and not mislead them.

As already mentioned on the methodology of the project and on the investigation process (Fig. 1.1) the benchmarking will determine the path to the initial choice of the indicators. On the next chapter it will be described.

3. DEVELOPMENT

As already mentioned on the methodology definition, the development of this project relies on a cyclical process which means it is an iterative method used for the continuous control and improvement of the artifacts. To start the process, an initial suggestion must be made. This will lead to the implementation and finally to the evaluation of results. The evaluation will determine the beginning of a new cycle or the conclusion of the project.

To start the first suggestion, a benchmarking was conducted in order to have an initial list of indicators to follow on the first try. The presentation of it is the first section of this chapter followed by the presentation of the indicators to use on the initial mockup as well the construction of the mockups.

The chapter ends with the construction of the mockups and with the presentation of the graphic rules manual.

3.1. BENCHMARKING

If there are different theories about the definition of a smart city, even more ambiguous will be trying to find out the correct way to measure performance. The lack of a clear and widely usable definition and such as delimitation areas and indicators makes it difficult to compare or measure cities in this context (Afonso, Brito, & Álvaro, 2015).

Different methods and measurement indicators have been developed so far according to the several meanings of the concept but usually the existing indicators are often not standardized, consistent, or comparable over time or across cities. So, they will never be completely reliable and accurate. The fundamental problem is that the variety of indicators lacks consistency and comparability (Mavric & Bobek, 2015).

Due to this fact, there is no correct way or an index to follow to evaluate the performance of Cascais. So, to have a starting point, a benchmarking was conducted and five cities and five frameworks were selected for analysis.

Each city is individual and unique. Different people living in different places have different values and it is nearly impossible to find out a universal way of measuring performance of all cities. Big cities have different characteristics from the small ones as well as the ones located on the coast, the Asian ones, and so on. With this in consideration, and after an extensive analysis of the many existing frameworks, were selected five frameworks of interest that seem to be able to take into account different locations, people and cultures.

The first of all was the ISO[2] 37120 (2014): an international standardization of indicators for city services and quality of life. This set of standardized indicators provides a uniform approach to what is measured, and how that measurement is to be undertaken. As a list, it does not provide a value judgment, a threshold or a target numerical value for the indicators. These indicators can be used to track and monitor progress on city performance.

[2] ISO (the International Organization for Standardization) is a worldwide federation of national standards.

With the ISO 37120 as a basis, the World Bank (2009) with support of University of Toronto, creates the Global City Indicator Facility. This is the second used framework and help cities with performance monitoring by providing a framework to facilitate consistent and comparative collection of city indicators.

The next one was proposed by ITU (2015), the United Nations specialized agency for Information and Communication Technologies that works to standardize the many areas of the ICT subject. Together with the United Nations Economic Commission for Europe (UNECE) developed a set of KPIs for smart cities that they believe to assess how smart cities have been in accomplishing their goals.

The ITU-UNECE framework is followed by the indicators used on a solution developed by the Open Government of the United States. Is a solution called Civic Dashboards (n.d.) and its major goal is to transform open data in actionable information. It aggregates data from various sources and provides a set of indicators to help users to get insights.

The last one under analysis is the Reference Framework for Sustainable Cities (n.d.). A web tool created to guide cities to sustainable development through five dimensions.

Regarding to the chosen cities, when the initial research about the subject of dashboarding open data of smart cities was initiated it became clear that only a few cities had public solutions on this area. The few that have something relating to dashboards of performance had real-time solutions of a global overview of the city and no monitoring of their data. Example of this fact is the city of Sydney (see Figure 3.1). Their city's dashboard only shows a brief overview of the real-time conditions like the weather, the transportation network, live traffic cameras, news or trends. They do not have records of analysis of open data generated in the city, trends or status evaluation of a few dimensions.

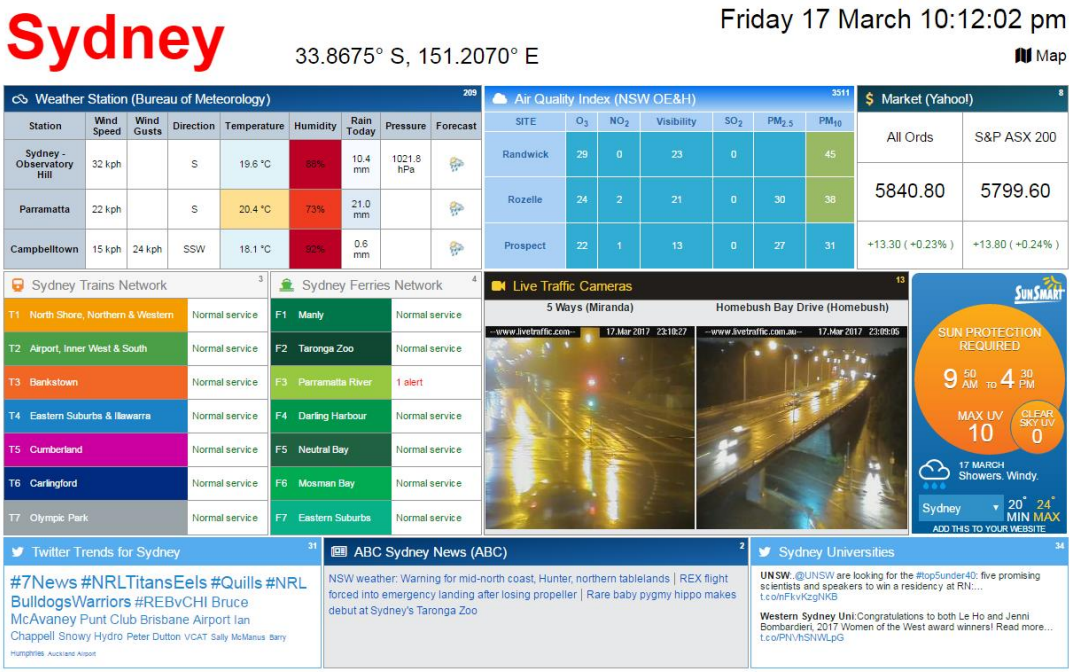

Figure 3.1 - Sydney city dashboard (http://citydashboard.be.unsw.edu.au/)

Whence, the selection of the five smart cities was based on their capacity to monitor open data and release indicators that demonstrate their performance. An extensive analysis of existing city dashboards and performance metrics was carried out, starting with the considered best smart cities. But then, it was concluded that the smartest and biggest cities (despite the example of London) are least concerned in releasing data analyzes, dashboards and indicators. They have their data public and available but are other cities that perform better on this field.

On the Table 3.1 the results of the referred analysis are shown. It was conducted a search using the key words *city dashboard*, *city performance dashboard* and *city indicators dashboard*.

Cities	Result	Source
CityDashboard: Birmingham, Brighton, Cardiff, Edinburgh, Leeds, Manchester Madrid Sydney Venice	Performance dashboard with no statistical data or analysis. Real-time indicators like for example: Air Pollution, Noise, Weather Conditions, Transportation Status, Traffic Cameras and News.	http://citydashboard.org/choose.php http://ceiboard.dit.upm.es/dashboard/sck_pub http://citydashboard.be.unsw.edu.au/ http://dashboard.cityknowledge.net/#/venice
Calgary Edmonton Los Angeles Dublin London	Interesting set of indicators to capture city performance. In the most cases it is presented the following features: - Indicator with related measures, metadata and behavior over time; - Importance of the indicator and the actions undertaken to improve performance; - Target and comparisons.	http://www.calgary.ca/General/Pages/CitizenDashboard/Citizen-Dashboard-Landing.aspx https://dashboard.edmonton.ca/ http://dashboard.lamayor.org/ http://www.dublindashboard.ie/pages/index https://data.london.gov.uk/
Glasgow Amsterdam	Under Construction	http://futurecity.glasgow.gov.uk/dashboards/ http://citydashboard.waag.org/
Boston, Albuquerque, Surrey, Toronto, Tampa, Muskegon, Rockford, Adrian, Melbourne, Waterloo, Seattle, Portland, Bellevue, Texas, Galway, Kansas,	Interesting set of indicators but not related with the objectives of the project. They have one of the following issues: - Do not display the indicators that are measuring the city performance into a dynamic single-screen; - The information is presented in an info graphic format; - The information is not related with the subject under study; - They adjective a dashboard as	https://www.cityofboston.gov/mayorsdashboard/ https://www.cabq.gov/economic-dashboard/ http://dashboard.surrey.ca/ http://www1.toronto.ca/wps/portal/contentonly?vgnextoid=9792de0096180510VgnVCM10000071d60f89RCRD https://www.tampagov.net/metrics/planning/com-issued-all http://www.muskegon-mi.gov/city-of-muskegon-dashboard/ https://accessmygov.com/MunicipalDashboard/Performance?uid=180

Jersey, Plano, Washington DC, Chicago,…	a list of indicators.	http://adriancity.com/transparency/dashboard/ https://www.melbourne.vic.gov.au/about-council/our-performance/Pages/quarterly-services-dashboard.aspx http://www.waterloo.ca/en/government/performancedashboard.asp https://performance.seattle.gov/ https://www.portlandoregon.gov/cbo/67124 http://www.ci.bellevue.wa.us/performance-dashboards.htm https://data.austintexas.gov/stories/s/Citywide-Dashboard/2tzx-kje9 http://galwaydashboard.ie/ https://kcstat.kcmo.org/ http://data.jerseycitynj.gov/showcase https://dashboard.plano.gov/ https://dc.gov/trackdc https://www.cityofchicago.org/city/en/depts/cdot/dataset/cdot_performancemanagementdashboard.html

Table 3.1 - Results of the reasearch to the constituents of the benchmarking

It is possible to conclude that the chosen cities to the benchmarking were: Edmonton, Calgary, Los Angeles, Dublin and London.

After the choice of the five frameworks and the five cities, for each one was constructed a table with the dimensions and indicators (see Appendices 7.1 to 7.4) that are used to characterize and monitor the performance of the city. Then, the various indicators were crossed and the Table 3.2 emerges composed by the indicators (related to the dimensions under study) that appear in at least three of the portals under analysis.

This process is illustrated bellow on Figure 3.2:

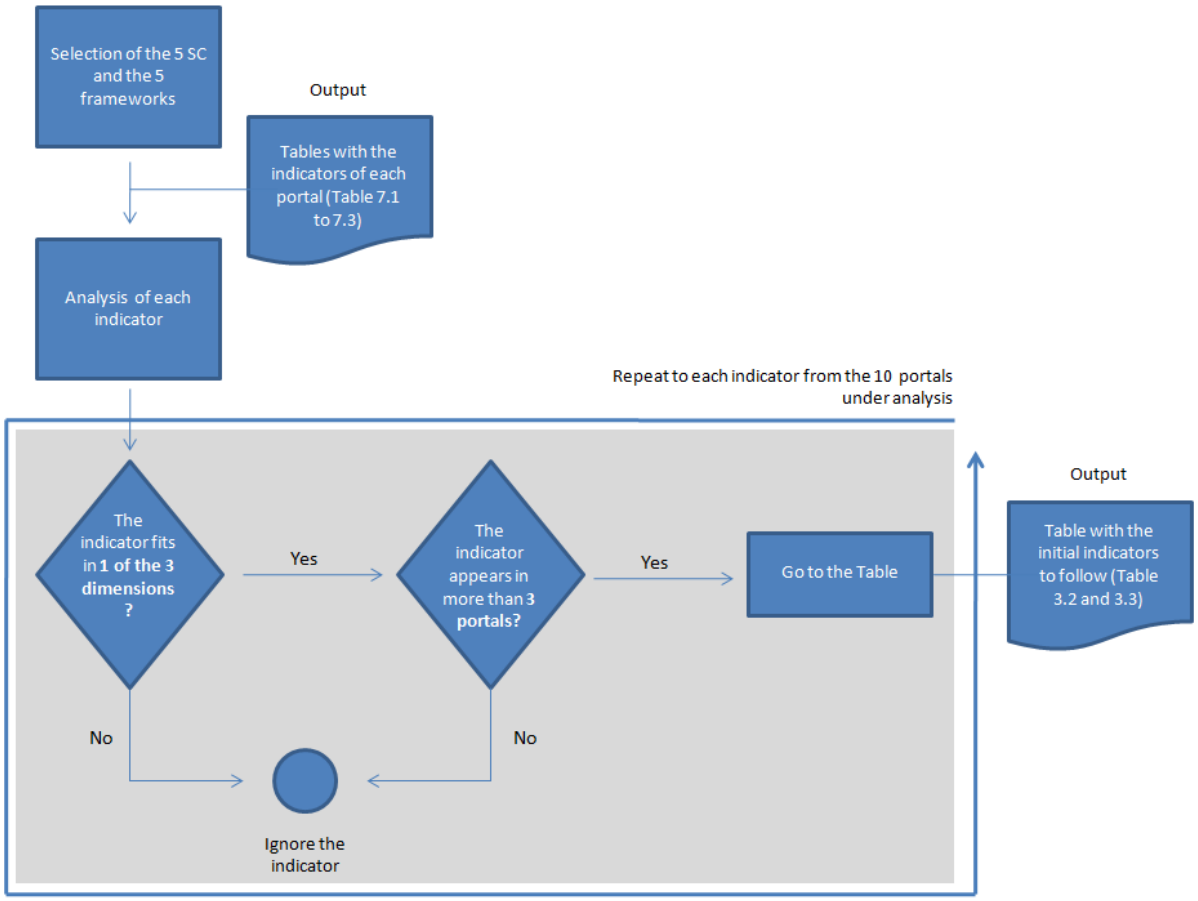

Figure 3.2 - Benchmarking process

After this process was concluded, from the Table 3.2 the metrics more recurrent were analyzed and the Table 3.3 constructed. From this, the initial choice of the first indicators to the dashboard was made. The resulting metrics of the benchmarking will not be completely applied on the mockup once they should be adapted to the characteristics of Cascais, to the availability of data and to the user's interest. The set of indicators that are part of the initial mockup of the dashboard will be presented on the next section.

	THEME-INDICATOR	Cities					Frameworks				
		LONDON	DUBLIN	LOS ANGELES	EDMONTON	CALGARY	ISO 37120	GCIF	ITU	RFSC	CIVIC D.
ECONOMY	Unemployment	X	X	X	X	X	X	X			X
	Employment	X	X	X			X	X	X	X	
	Population in Poverty			X			X	X		X	X
	GDP				X			X			X
	GINI								X	X	X
	Nr of Business				X		X	X	X		X
	Nr of New Patents						X	X	X		
	Housing	X	X	X	X	X					X
	International Visitors	X	X	X							
SOCIAL	Property Crime Rate			X		X	X				X
	Recorded Crime	X	X	X	X						X
	Police Officers	X		X			X	X			
	Firefighters			X			X	X			
	Education Qualifications	X	X				X	X	X		X
	Demographics of the Population	X	X					X			X
ENVIRONMENT	Waste Produced		X	X	X	X	X	X	X	X	
	Water per Capita		X	X		X	X	X	X	X	
	Water Quality		X						X		
	Air Quality Index		X	X					X		
	Sound Level		X				X		X		
	PM2.5 Levels	X					X				
	NO2 Emissions	X					X				
	Energy Use			X			X	X	X		
	Greenhouse Gas Emissions	X		X	X	X	X	X	X	X	
	Building Energy Use			X			X		X		
	Green Area						X	X	X	X	

Table 3.2 - Indicators (related to the dimensions under study) that appear in at least three of the portals under analysis.

	THEME-INDICATOR	Cities					Frameworks				
		LONDON	DUBLIN	LOS ANGELES	EDMONTON	CALGARY	ISO 37120	GCIF	ITU	RFSC	CIVIC D.
ECONOMY	Unemployment	Unemployment rates for those aged 16 or over.	Numbers in unemployed	Unemployment rate gap between LA County and the City of LA	Unemployment rate	Unemployment rate	Unemployment rate, Youth unemployment rate	Annual average unemployment rate	_____	_____	Unemployment rate
	Employment	Employment projections by sector and by borough	Numbers in employed, Numbers by employment sector	Total employment	_____	_____	Percentage of persons in full-time employment	Total employment, Employment percentage change based on the last 5 years, Percentage of full-time employment	Employment Rate, Creative industry employment, Tourism industry employment	Employment rate for women and men aged 20-64	_____
	Population in Poverty	_____	_____	Percentage of population in poverty			Percentage of population in poverty	Percentage of population in poverty	_____	Population at risk of poverty	Percent Living in Poverty
	GDP			_____	GDP		_____	GDP, GDP per capita	_____	_____	GDP per Capita
	GINI				_____			_____	Gini coefficient	Gini coefficient	Gini income distribution
	Nr of Business				Growth in the Nr of Small & Medium Business		Number of businesses per 100 000 population	Number of businesses per 100 000 population	% of Small and Medium Enterprises	_____	Number of businesses per 100 000 population
	Nr of New Patents				_____		New patents per 100 000 inhabitants per year	New patents per 100 000 inhabitants per year	Nr of New patents		Patents per 100 000 inhabitants

	THEME-INDICATOR	Cities					Frameworks				
		LONDON	DUBLIN	LOS ANGELES	EDMONTON	CALGARY	ISO 37120	GCIF	ITU	RFSC	CIVIC D.
	Housing	Average Rent Levels, Average House Prices	Average monthly rent, Average House Prices	Housing Permits Issued, Nr of new houses	Permit Applications, New units per quarter	Construction Permits Issued, New units per month, Average House Prices	_____	_____	_____	_____	Building Permits per 1000 Residents, Average monthly rent
	International Visitors	Number of visitors, Foreign Born, Country of origin of the visitors	Number of visitors	Number of visitors	_____	_____					_____
SOCIAL	Property Crime Rate	_____	_____	Property Crime Percentage	_____	Property Crime Rate	Property Crimes per 100 000	_____	_____	_____	Property Crimes per 100 000
	Recorded Crime	Number of Offences	Number of Offences	Crime Percentage	Crime Severity Index	Person Crime Rate	_____				Homicides, Violent Crimes and highway fatalities per 100 000
	Police Officers	Number of Officers	_____	Number of Officers	_____	_____	Number of Officers	Number of Officers		_____	_____
	Firefighters	_____		Number of firefighters			Number of firefighters	Number of firefighters			
	Education Qualifications	People 25-64 with higher level qualifications	Highest Level of Education for Persons Aged 15 and Over, Number of students by year of learning	_____	_____	_____	Number of higher education degrees per 100 000 population	Number of higher education degrees per 100 000 population	Higher education ratio, School enrollment		Percentage with High School or higher, with bachelors degree or higher

	THEME-INDICATOR	Cities					Frameworks				
		LONDON	DUBLIN	LOS ANGELES	EDMONTON	CALGARY	ISO 37120	GCIF	ITU	RFSC	CIVIC D.
	Demographics of the Population	Number of inhabitants	Number of inhabitants, Age profiles, Foreign born				_____	Number of inhabitants, People per Sq Mile, Age profiles	_____		People per Sq Mile, Percent foreign born, Percent 65 and over

ENVIRONMENT	Waste Produced	Kg of waste produced per household, Recycling rate	Waste Produced per Capita, Recycling rate	Waste Diversion Rate	Waste Diversion	Kilograms of waste landfilled per person	Percentage of waste recycled, Waste collected per capita	Percentage of waste recycled	Percentage of waste recycled	Waste Produced per Capita	
	Water per Capita		Annual Water Consumption per Capita	Avg Daily Use Per Capita		Daily water consumption	Total water consumption per capita (l/day)	Total water consumption per capita (l/day)	Total water consumption per capita (l/day)	Total water consumption per capita (l/day)	
	Water Quality		Water Quality Trends	_____					Quality of drinking water		
	Air Quality Index	_____	Current Air Quality Index	Number of days of unhealthy air pollution levels	_____		_____		Air Quality Index		_____
	Sound Level		Sound Level			_____	Noise pollution	_____	Exposure to noise	_____	
	PM2.5 Levels	Average PM2.5 Levels					PM2.5 concentration				
	NO2 Emissions	Average Nitrogen Dioxide Levels	_____	_____			NO2 (nitrogen dioxide) concentration		_____		

	THEME-INDICATOR	Cities					Frameworks				
		LONDON	DUBLIN	LOS ANGELES	EDMONTON	CALGARY	ISO 37120	GCIF	ITU	RFSC	CIVIC D.
	Energy Use	_____		Power average use			Total energy use per capita	Total energy use per capita	Total energy use per capita	_____	
	Greenhouse Gas Emissions	Carbon Dioxide Emissions by Sector		Greenhouse Gas Emissions	Greenhouse Gas Emissions	Greenhouse Gas Emissions	Greenhouse gas emissions measured in tonnes per capita	Greenhouse gas emissions measured in tonnes per capita	Greenhouse Gas Emissions	Greenhouse Gas Emissions	
	Building Energy Use	_____		Average Building Energy Use	_____	_____	Total energy consumption of public buidings per year	_____	Annual energy consumption of public buildings	_____	
	Green Area			_____			Green area per 100 000 population	Green area per 100 000 population	Green area per 100 000 population	Green zones	

Table 3.3 - Table with the metrics used on the most recurrent indicators on the 10 portals under analysis

3.1.1. Indicators Based on the Benchmarking

The constructed table is the benchmarking result and, as previously mentioned, it will be the starting point for the choice of the indicators.

Whence, the metrics used to calculate the next indicators were chosen based on the fact that are the most recurrent on the benchmarking.

For each indicator, most recurrent on the benchmarking, the following process (Figure 3.3) was applied:

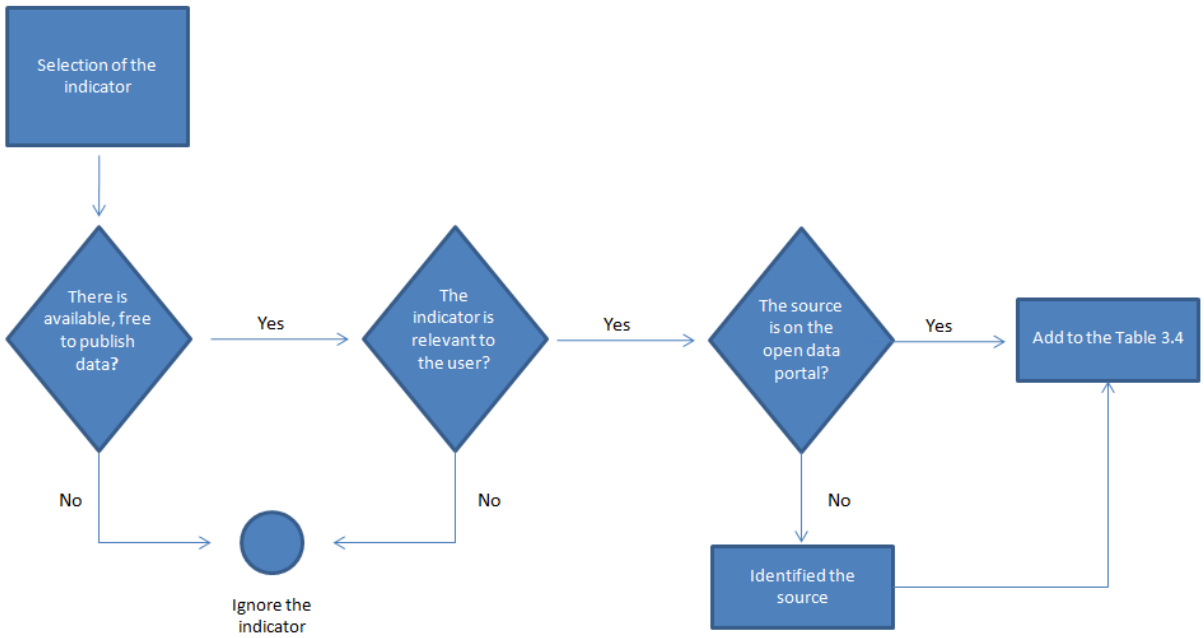

Figure 3.3 – Indicators process

The result of this process is a list of potential indicators to measure the performance of Cascais. Once this list does not contemplate the characteristics of Cascais, small adaptations will be considered.

Whenever it is necessary to carry out calculations, the estimate population of the current year under analysis should be used. For example, police officers per inhabitant:

Number of police officers in 2016 / Estimation of the population in 2016;

The official values for the population are released in each 10 years, the other years have estimations. The most recent number of inhabitants is an estimate of the year 2015 and the last official value is from 2011 (Statistics Portugal, 2011).

Each indicator of the ***economic*** dimension will be explained on the following points:

Unemployment

- This indicator is a rate that defines the weight of the unemployed population over the total active population. The calculation of this indicator is:

  *(Unemployed Population / Active Population) * 100*

  Note: Active population is the labor available to work, including the working population (the workers who are employed) and the unemployed.

Employment

- This indicator is a rate that defines the relationship between the employed population and the population aged 15 and over. The calculation of this indicator is:

  *(Employed population / Resident population aged 15 and over) * 100*

Population in Poverty, GINI Coefficient, GDP and Patents

Although these indicators are recurrent in the benchmarking table, there is no data available at the municipality level. The existing and free-to-publish data related to these topics are only of national level so these indicators will not be used.

To replace them, a potential indicator was identified according to the available data and interest for the dashboard user:

Purchasing Power

The Portuguese National Institute of Statistics conducted a study in 2015 about the purchasing power in the municipalities of the country. The purchasing power per capita indicator aims to understand the daily purchasing power per inhabitant. Since Cascais is one of the municipalities with the greatest purchasing power in the country, is interesting, from an economic point of view, to present this indicator. This is due to the fact that, for example, if an investor is looking to find a strategic place to invest in Portugal, will find that Cascais is an attractive place.

- This composite indicator is intended to translate purchasing power into per capita terms. It is an index number with a value of 100 in the country average, which compares the purchasing power expressed daily.

Number of Business

Although the most used metric to calculate this indicator in the Table 3.3 is the number of businesses per 100 000 inhabitants, to the Cascais example it was considered more interesting to present the absolute number of businesses per sector of economic activity.

- The indicator will be the number of business in order to be possible to understand which area has more or less companies.

- To complete this indicator, it was considered also important to present the Survival Rate of Business (also interesting from an investment point of view). The calculation of this indicator is:

  *(Enterprises active in the year x with 2 years of existence / Enterprises born in the previous 2 years) * 100*

Housing

As it is possible to see on Table 3.3, the most used indicators are average monthly rent and average house prices (m^2/month or average value/month for the rental values and average price per meter for house prices).

Due to a lack of data, it will be only presented the average house price indicator. This is relevant again to potential investors or even for potential newcomers who are looking for a new place to live.

- The indicator is composed by the average value of the houses per m² in euros.

International Visitors

As it is possible to confirm on Table 3.3, the most frequent indicator is the Number of Visitors.

- Although, due to the constant high level of tourism in Cascais, it was considered more interesting to present the average stay than the number of visitors. The calculation of this indicator is:

  Nights in the year x / Guests in the year x

Each indicator of the ***social*** dimension will be explained on the following points:

Crime

The benchmarking proposal to this subject is an indicator of the property crime and other with the number of offences. Nevertheless, to have a complete indicator of the crime in the county, it will be presented the percentage of crime in all categories as the total of crime recorded.).

- The calculation of this indicator is:

  *(Number of crimes by type in the year x / Resident population in the year x) * 100*

Security Agents

The benchmarking proposal to this subject is an indicator of the number of police officers and the number of firefighters.

- To have a comparison term, it will be presented the number of inhabitants per police officer.

- Instead of the same indicator to the firefighters, and because the five local corporations work as a network and not only in a close area, it was considered more interesting to present an indicator composed by a map with the location of the firefighting corporations and with the absolute value of firefighters in each one.

Education Qualification

The benchmarking proposal to this subject is an indicator only related to the population with high level qualifications.

- To present an overview of the schooling degree of the population, the indicator will be completed with the other levels of education: number of inhabitants per schooling degree (no schooling, basic first cycle, basic second cycle, basic third cycle, secondary and superior level).

Demographics of the Population

Following the benchmarking results, the mockup will also have the number of inhabitants of the municipality and an age profile.

- The age profile will be composed by the number of inhabitants by age group (0-14, 15-14, 25-64 and 65+).

Each indicator of the ***environmental*** dimension will be explained on the following points:

Waste Produced by the Inhabitants

Once again following the results obtained in the benchmarking, the two indicators to introduce on this subject will be the percentage of waste produced per inhabitant (Kg/inhabitant) and the diversification of collected waste (collected waste by type).

- The calculation of these indicators are:

  Kg of waste collected in the year x / Resident population in the year x

  Absolute value of tons of waste collected by waste type

Water

The indicator used to capture the data related to the water of the municipality should be, such as in the benchmarking, the average consumption per capita (liters/day).

But, since in Cascais the water management belongs to a private company, there is no data free to publish in this area.

- To replace it, other indicator considered interesting is the water quality. This value should represent the percentage of secure water in Cascais last year.

Air Quality

As the benchmarking suggests, it will be presented the values of the following pollutants: NO_2, SO_2, O_3, CO and PM_{10}.

- These values will be presented in a map showing the locations where they were measured.

Greenhouse Gas Emissions

Despite being an important factor in the benchmarking, the previous indicator correctly shows the air quality so this one will not be used since it is believed to be redundant.

Energy Use

In the benchmarking, the indicator used is the total energy use per inhabitant (in kWh). But, for a user perspective, it was considered more interesting capture this data showing the evolution of the domestic energy consumption per inhabitant and the energy consumption by type. Thus, it will be easy to the user to understand where the energy has been spent and the evolution of the use of energy by the inhabitants of the municipality.

Although the results of the benchmarking also suggest the use of the indicator Building Energy Use, since it has been chosen to present the use of electricity by categories, it does not make sense to follow this suggestion.

- The calculation of this indicator is:

  Domestic consumption of electricity (kWh) in the year x / Resident population in the year x

  Absolute value (in kWh) of energy consumption by business sector

Green Area

As already mentioned, the population of Cascais is composed by 206 479 inhabitants. So, the indicator Green Area per 100 000 inhabitants (suggested by the benchmarking) does not tell us a great description.

- The option is to present this subject as a value of total m^2 per inhabitant. The calculation of this indicator is:

  Total m^2 of green areas in 2015 / Estimate population in 2015

3.1.2. Other Indicators Of Interest

The benchmarking carried out was important to define the first indicators and to chart the way forward but does not mean that is a static process. The municipality of Cascais is unique and has its own characteristics so the dashboard should be completed with indicators that fit with Cascais.

On this section, other indicators considered interesting to capture the performance of Cascais will be presented. These indicators can be present on the benchmarking but are not recurrent or can be result of the previous research. Before the five portals were chosen to the benchmarking, other frameworks were analyzed as well different proposals of indexes and performance measures. It is possible to highlight the example of the European Smart Cities Ranking (Vienna University of Technology, 2007) or the Indicators for Sustainable Cities (European Commission, 2015). Of these, were being withdrawn potential indicators for the Cascais example. The following list is composed by those considered essential to capture the performance of the municipality.

Number of students

Following the Dublin example, it was considered interesting to present the number of students by learning cycle and by school location. It is important for example for an inhabitant choosing the school for the children or for organizations who want to create partnerships with the schools.

- This indicator will be presented as a map.

Waiting Time of the Services

Since the health agencies in the municipality are in the domain of the central government or are private, it is not possible to the municipality to access or release the data with these related. Therefore, although indicators of type Emergency Call Volume, Emergency Call Duration, Emergency Request Created or Emergency Call Average Wait Time are very recurrent in the portals under analysis, they cannot be constituents of the dashboard. These examples of indicators will be used applied to the attendance of the services of the municipality.

- It will be presented the monthly average wait time in each service in 2016.

Voter Participation

To get an idea of how the population is participative or not is important to show the last election results (in 2013).

- It should be presented with the percentage of null votes, white votes and voters.

(This is based on the indicator “Political Activity of Inhabitants” from the European Smart Cities Ranking (Vienna University of Technology, 2007) and on the “Voter Participation” from ISO and GCIF)

Pets Rescued

Cascais is a municipality that cares about having all the animals in safety.

- To show that, is interesting to present the relationship between the number of animals kept on the Animals Association and those who were adopted, rescued or handed out.

(This is based on the indicator “Pets Rescued” from the Los Angeles and Edmonton examples)

Occurrences of the Civil Protection

Although the health data is not available, it is still important to have some information about it.

- The existing option is to present the evolution of occurrences of the Civil Protection by type of occurrence.

Beach Water Quality

Since Cascais has more than fifteen beaches very appreciated by the inhabitants and visitors, it is important to show an indicator that demonstrates the water quality of those beaches.

- It should be a map with the location and the category of water quality of each beach according to the classification of the National Water Resources Information System (2016): Bad, Weak, Medium, Good and Excellent.

(This is based on the indicator "Beach Water Quality" from the Los Angeles example)

Kilometers of Bicycle paths

- Since Cascais has a great bicycle track and broad sidewalk is relevant to show the total kilometers of bicycle paths.

(This is based on the indicator "Kilometers of Bicycle Path" from ISO)

Urban Density

To have information about the population density the indicator to use is the number of inhabitants per square kilometer.

- The last official value for the kilometers of Cascais is from 2013 so the calculation of this indicator is:

  Estimate population in 2013 / Total km^2 of Cascais in 2013

(This is based on the indicator "Urban Density" from the Civic Dashboards and the Indicators for Sustainable Cities (European Commission, 2015)).

On the Table 3.4 is possible to see the final indicators list used to construct the first mockups, introduced in the next section. They are organized by dimension and the highlighted lines are the ones that were added to the benchmarking results.

If the source is INE, it means that the dataset that is feeding the indicator comes from the Statistics Portugal (https://www.ine.pt), a webpage containing a repository of national and public statistics. If the source is CMC (*Câmara Municipal de Cascais*) it means that the dataset comes from internal source. It is not yet on the Cascais Data Portal but is in changes to become part of the portal. The rest of the sources are public authorities responsible for data from certain sectors.

	Indicator	Source	Data Period	Type of Visualization
ECONOMY	Unemployment Rate	INE	2011	Single value
	Employment Rate	INE	2011	Single value
	Purchasing Power	INE	2000,2002,2007,2009,2011,2013, 2015	Comparison over time (line or bar chart)
	Number of Business per Type	INE	2015	Composition (pie chart)
	Survival Rate of Business	CMC	2012 to 2015	KPI
	Average Housing Price	INE	2009 to 2015	Comparison over time (line or bar chart)
	Average Visitor Stay	INE	2010 to 2013	Comparison over time (line or bar chart)
SOCIAL (Security, demographics)	Total Crime Rate	INE	2011 to 2015	Single value
	Crime Rate by Type	INE	2011 to 2015	Comparison over time (line or bar chart)
	Number of Inhabitants per Police Officer	CMC	2015	Single value
	Number of Firefighters per Corporation	CMC	2015	Single value
	Location of the Firefighting Corporations	Cascais Data Portal	2015	Map
	Number of Inhabitants	CMC	2015	Single value
	Inhabitants per Age	CMC	2015	Comparison among items (bar chart)
	Occurrences of the Civil Protection by Type	Cascais Data Portal	2006 to 2016	Composition (pie chart)
SOCIAL (Education, others)	Inhabitants per Schooling Degree	INE	1981,2001,2011	Comparison among items (bar chart)
	Location of Schools with Number of Students	Cascais Data Portal	2016	Map
	Average monthly wait time in the services	Cascais Data Portal	2016	Single value
	Percentage of Votes in the Elections	SGMAI	2013	Composition (pie chart)

	Percentage of Pets Recued	Cascais Data Portal	2000 to 2016	Composition (pie chart)
ENVIRONMNET	Waste Produced per Inhabitant (Tones/Year)	Cascais Data Portal	2009 to 2014	Comparison over time (line or bar chart)
	Waste Collected by Type	Cascais Data Portal	2014 to 2016	Composition (pie chart)
	Percentage of Secure Water	ERSAR	2015	Single value
	Air Quality	Cascais Data Portal	2015	Map
	Domestic Energy Use	Cascais Data Portal	2005 to 2010	Comparison over time (line or bar chart)
	Energy Consumption by Type	Cascais Data Portal	2010	Composition (pie chart)
	Green Area per Inhabitant	Cascais Data Portal	2015	Single value
	Classification of Beach Water	SNI RH	2016	Map
	Km of Bicycle Paths	CMC	2016	Single value
	Urban Density	CMC	2013	Single value

Table 3.4 - List of the indicators used to construct the first mockups

3.2. MOCKUPS

As it is possible to see on the following figures (Fig. 3.4 to 3.7) the first mockups were constructed with the aim of graphically thinking about the localization on the dashboard of the various indicators and the first visual guides.

The mockups do not have data or the final filters (data segments or categorical segments) but were useful before the following construction because they allowed the identification of two problems:

- The social theme has too many indicators that should be divided in sub-themes;
- There is evidence of a need for visual normalization between the various dashboards.

Once the dashboards support the modular construction and the essential single-screen, the maximum number considered correct after the construction of the mockups were twelve modules.

The initial indicators of the Social Mockup do not fit on a single-screen and once the sub-themes are unrelated do not make sense to put all together. It will not be respectful of the referred rules and the information will not have the needed space and will be confused.

The option to resolve this problem will be divided in two dashboards as it is possible to see on Figure 3.6 and 3.7.

To resolve the visual normalization between the dashboards and even to future dashboards constructed in Cascais, a manual of graphic rules was created and will be introduced in the next section.

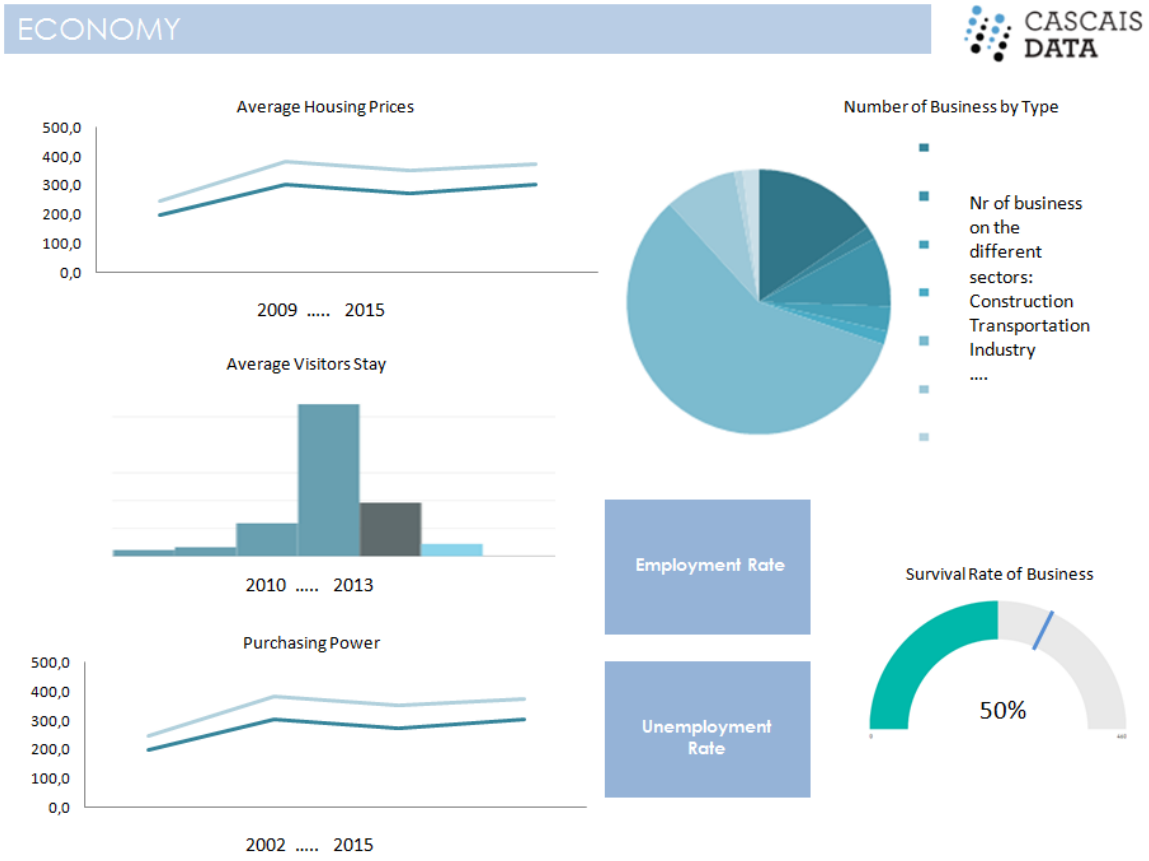

Figure 3.4 – Mockup of the economic dimension

Figure 3.5 – Mockup of the environmental dimension

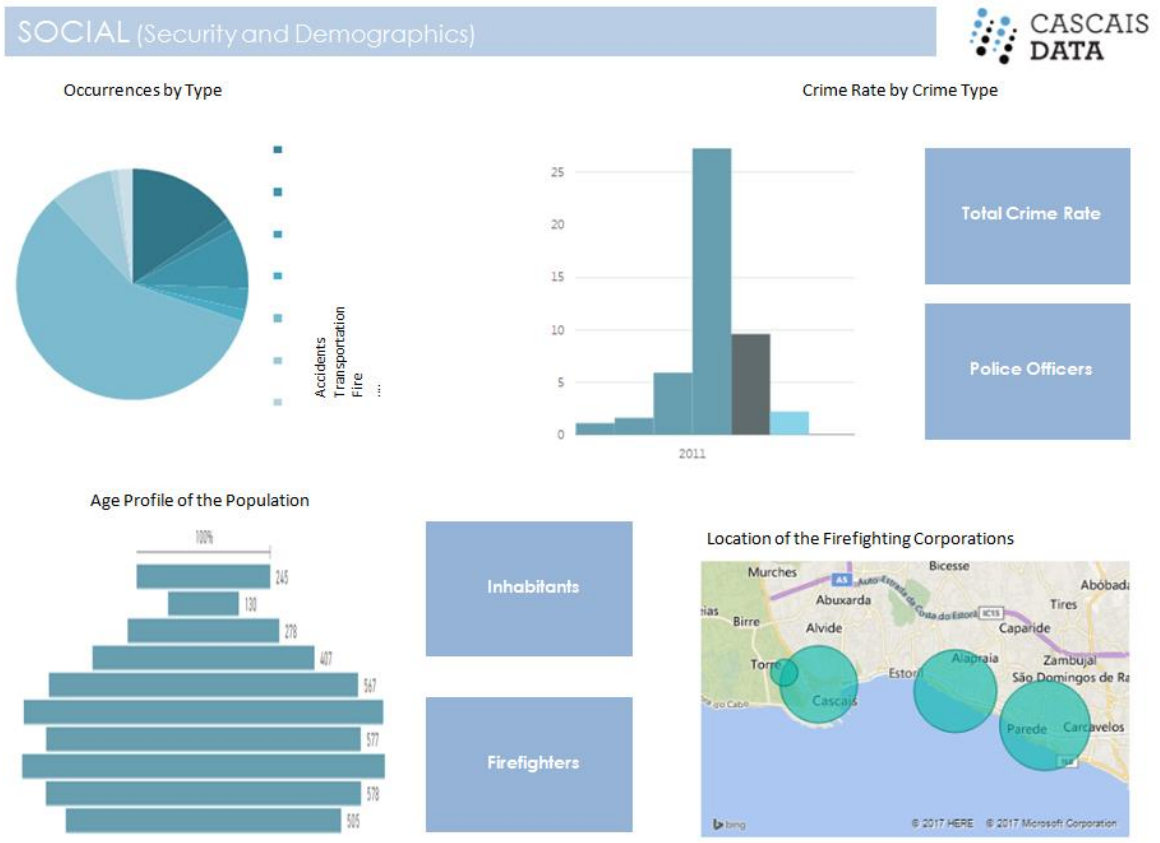

Figure 3.6 – Mockup of the social dimension

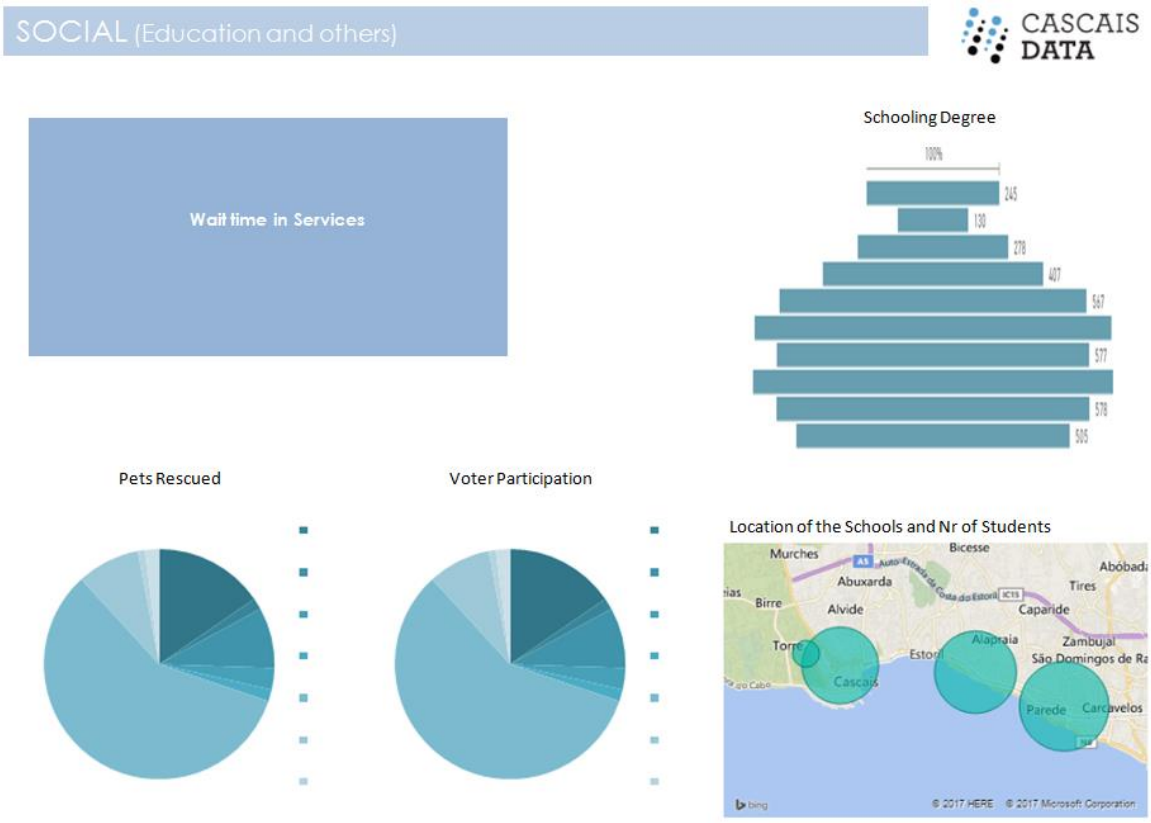

Figure 3.7 – Mockup of the social dimension

3.3. GRAPHIC RULES MANUAL

The purpose of this manual is to create visual normalization along the dashboards of the municipality of Cascais.

Different departments create their own dashboards with their specific goals and purposes. But if every department decide to publish them online in the Cascais Data Portal, it will be confused because there will not exist visual coherency between them.

Therefore, a set of rules were created and distributed along the various departments. On the following Table 3.5 it is possible to see an excerption of the Graphic Rules Manual. Due to the target of the Manual's user, the complete Manual is available in Portuguese, on the Appendix 7.5.

VISUAL NORMS	
Element	**Norm**
Title	Text: The initial of all constituent words of the metric heading must be upper case except for the articles and determinants of the sentence Letter color: C8C8C8 Background color: No fill Alignment: Left Letter size: 14
Background	Inactive
Chart Propotion	Inactive
Limit	Inactive
TERMINOLOGIAS	
Abbreviation of Number	Nº
Currency unit	€
Data format	DD/MM/YYYY
GENERAL LAYOUT RULES	
Dashboard Title (Text Box)	Letter color : 333333 Background color : C8C8C8 / Transparency: 50% Alignment: left Letter size: 32
Title:	X Position: 0 Y Position: 0 Width: 1280 Height: 55
CASCAIS COLORS	
Colors to be used in the charts	
C6AA76	8B6A38
E8927C	A6192E
A7A2C3	563D82
64CCC9	007367
4698CB	004976
77C5D5	007396
FDDA24	AC8400
ECA154	CB6015
71CC98	046A38

Table 3.5 - General visual rules of the dashboards

4. RESULTS

On this chapter, the final city performance dashboards will be presented and the results evaluated.

4.1. PERFORMANCE DASHBOARDS OF CASCAIS

As it is possible to notice, the mockups do not have data loaded. They are only sketches of how the visualizations will be displayed and which indicators will be presented.

As the referred processes mentioned, to the indicator be on the initial mockup it should have data available and free to publish. So, all the indicators that are part of the mockups respect this condition. A data collection for each indicator was carried out before the construction of the initial mockups (if the indicator doesn't have data available it cannot be part of the mockup).

One dataset per indicator was constructed and loaded in Microsoft Power BI (https://powerbi.microsoft.com). After the definition of the relational model of each dashboard, the visualizations were constructed. It is possible to see the dashboards constructed on Figure 4.1 to 4.4.

On these dashboards is possible to find some key insights about Cascais as foreseen in the initial goals.

On the **Economy** dashboard (Figure 4.1), by selecting the year of interest, the user will notice that the survival rate of business is growing over the past years. This is a positive fact but, it should not be ignored that, this value remains low and not favorable from an investment point of view. The municipality's management should try to create better measures to support the organizations.

Regarding the housing prices and the average stay of the visitors, the results are positively increasing which suggests an appreciation of the municipality.

Concerning to the purchasing power, although a downward trend is visible, Cascais stills one of the municipalities with the highest purchasing power of the country ("Onde vivem os Portugueses com maior poder de compra?", 2015).

The employment rate (although it is higher in Cascais than in Lisbon or Portugal) is not high and has been declining due to the economic crisis. The same phenomenon happens with the unemployment rate which has risen sharply on the last years.

The number of existing companies in Cascais is higher on the type "Administrative Activities".

On the **Environment** dashboard (Figure 4.2) it is possible to identify some issues. The production of waste and energy is tending to grow, which should alert the municipality's management to take measures to alert the population and to raise awareness between the inhabitants to act more responsibly.

As expected, the domestic type has the greater representation on the energy consumption as well the undifferentiated waste on the waste produced by type.

When the user selects a location on the Air Quality Map, will notice that the different locations doesn't have big variations of values which means that the air has an approximately constant quality

along the municipality. These values are satisfactory according to the metrics for each pollutant established by the Portuguese Environment Agency.

All the beaches have their water with a classification of Excellent with the exception of two that have a Good water quality (no beaches have Weak, Bad or Medium quality). In addition to being able to select only the beaches that present excellence in quality, this map also allows to verify the exact location of all the beaches (important, for example, to inform tourists).

Is also possible to conclude that there are more than 2 000 inhabitants per Km^2, approximately 127 m^2 of green areas per inhabitant, approximately 16 Km of bicycle paths and that practically all water that is distributed in the municipality is secure to drink.

On these **Social** dashboards (Figure 4.3 and 4.4) it is possible to see the last estimated number of inhabitants in Cascais as well their division per age group (the 25-64 group is the group with greater representation).

Concerning to the security of the municipality, if the user select the age filters, will verify that the crime rate has been growing which should alert the managers of the municipality. The type of crime with greater representation is the Crimes against Property, which should also alert the inhabitants to take preventive measures. On the map, is possible to see he location of each corporation of firefighters as well the number of firefighters in each of it.

Infrastructures are the category with more occurrences in the Civil Protection followed by the Strong Winds, characteristics of the area.

On the second social dashboard, some interesting information is given to the users. They can realize that the school degree of the population and know the location of each school and the number of students if they select one school.

When moving the date filter, the user will notice that the number of inhabitants who does not voted last elections is growing so the governors should take actions to improved and encouraging voting on this election year.

The pets rescued chart shows well the great job did by the municipality, over the past years, in protecting and caring about animals. When the user selects this chart, can see the number of pets adopted, deceased and missing.

With this dashboard the users also know which month has more waiting time last year on the several services. This can be useful in the perspective of the inhabitant who seeks to know the best month to address the services.

Citizens can choose and make decisions based on facts and truthful information. Reducing waiting time, the quality of life of the citizen has been improved allowing them to become smarter.

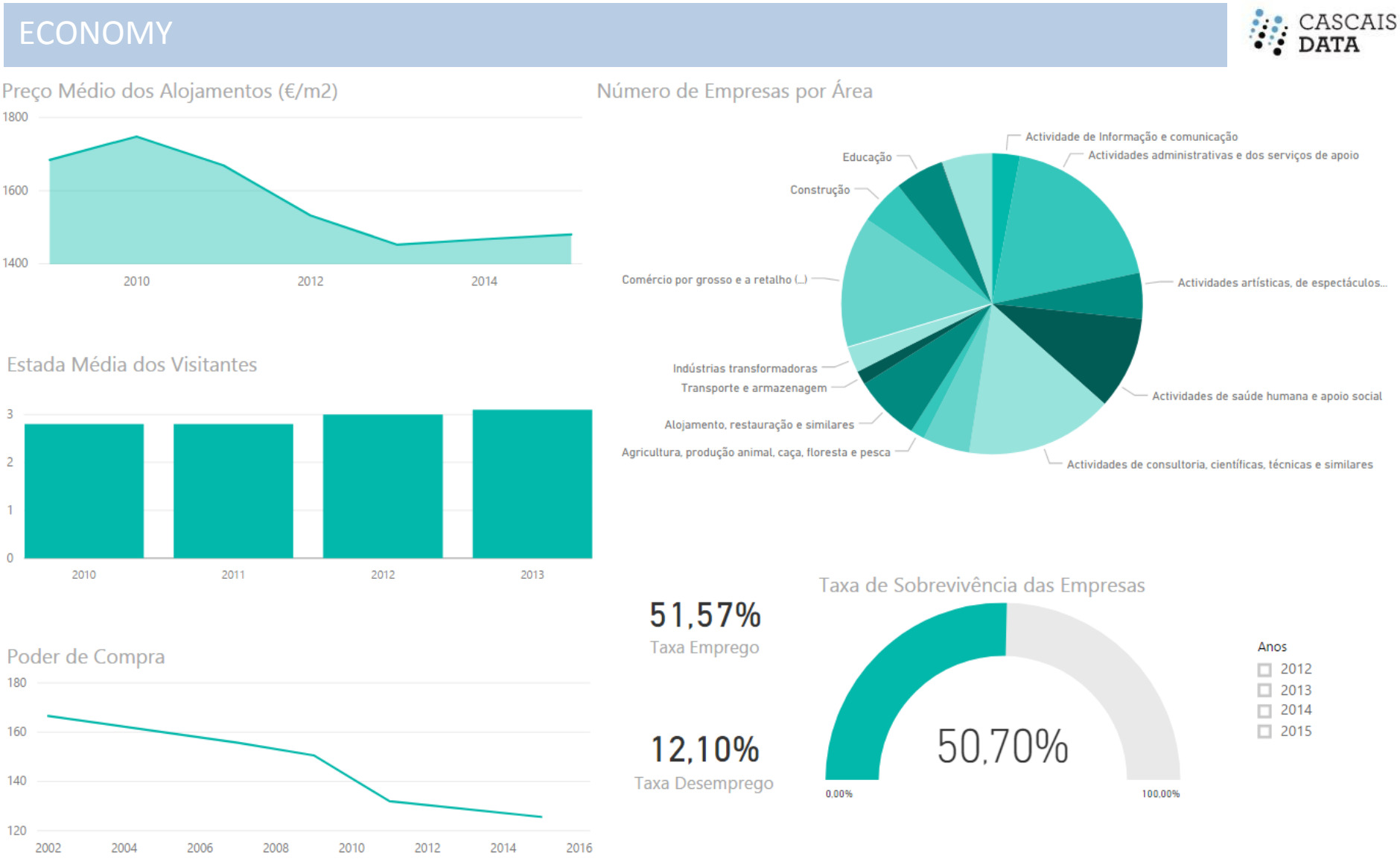

Figure 4.1 – Economic Dashboard (the text is in Portuguese due to the target of the artifact)

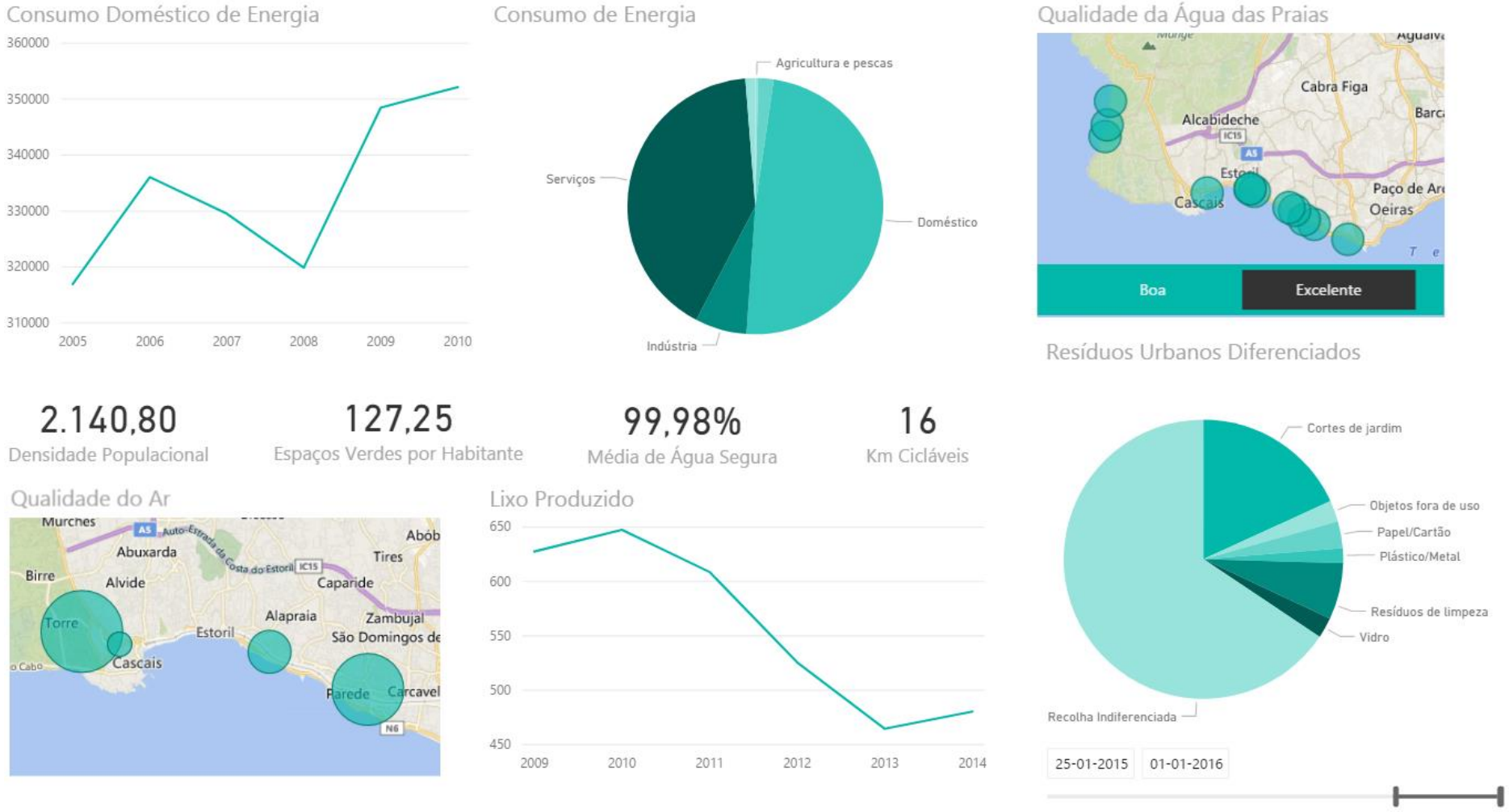

Figure 4.2 – Environmental Dashboard (the text is in Portuguese due to the target of the artifact)

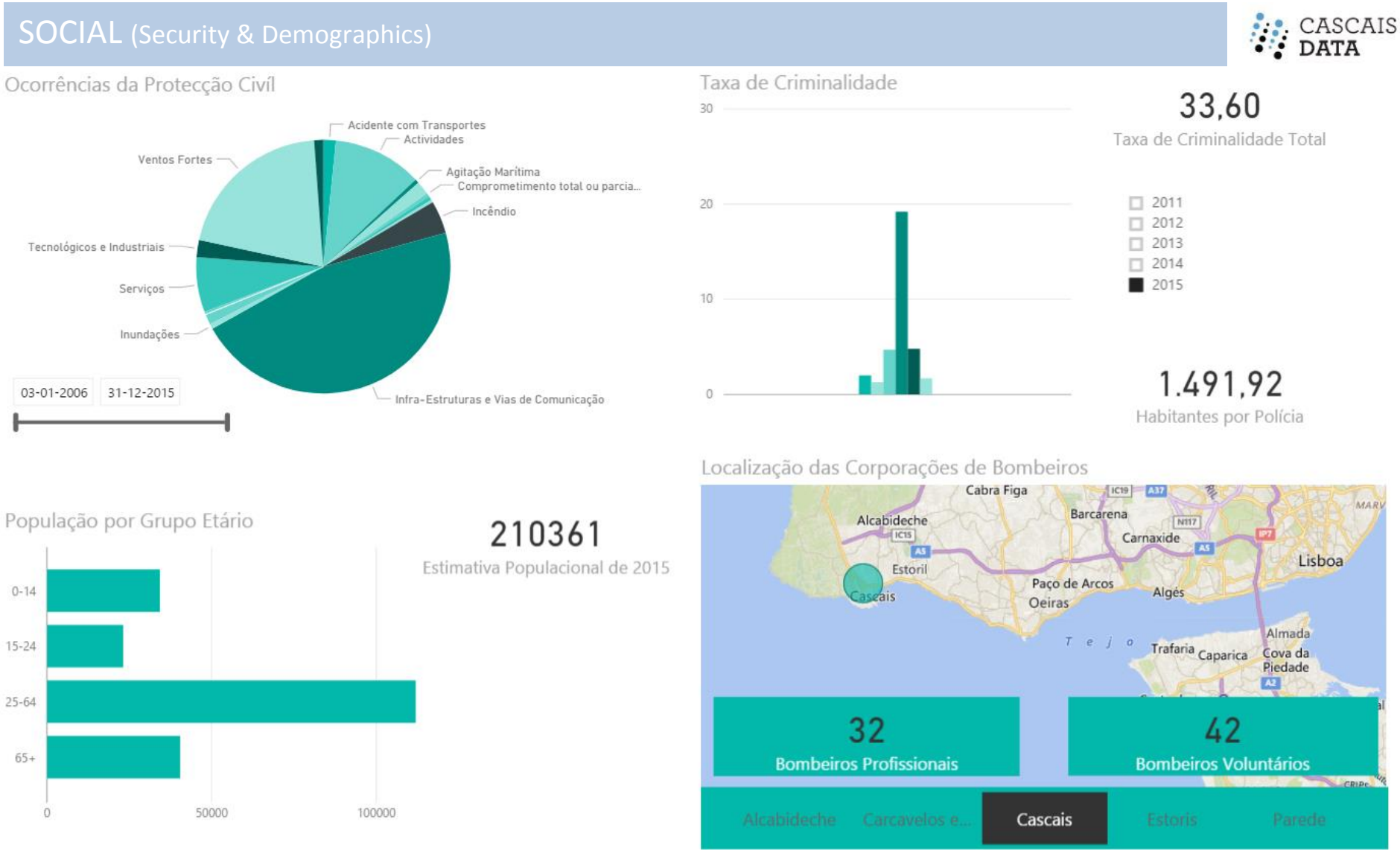

Figure 4.3 – Social - Security and demographics - Dashboard (the text is in Portuguese due to the target of the artifact)

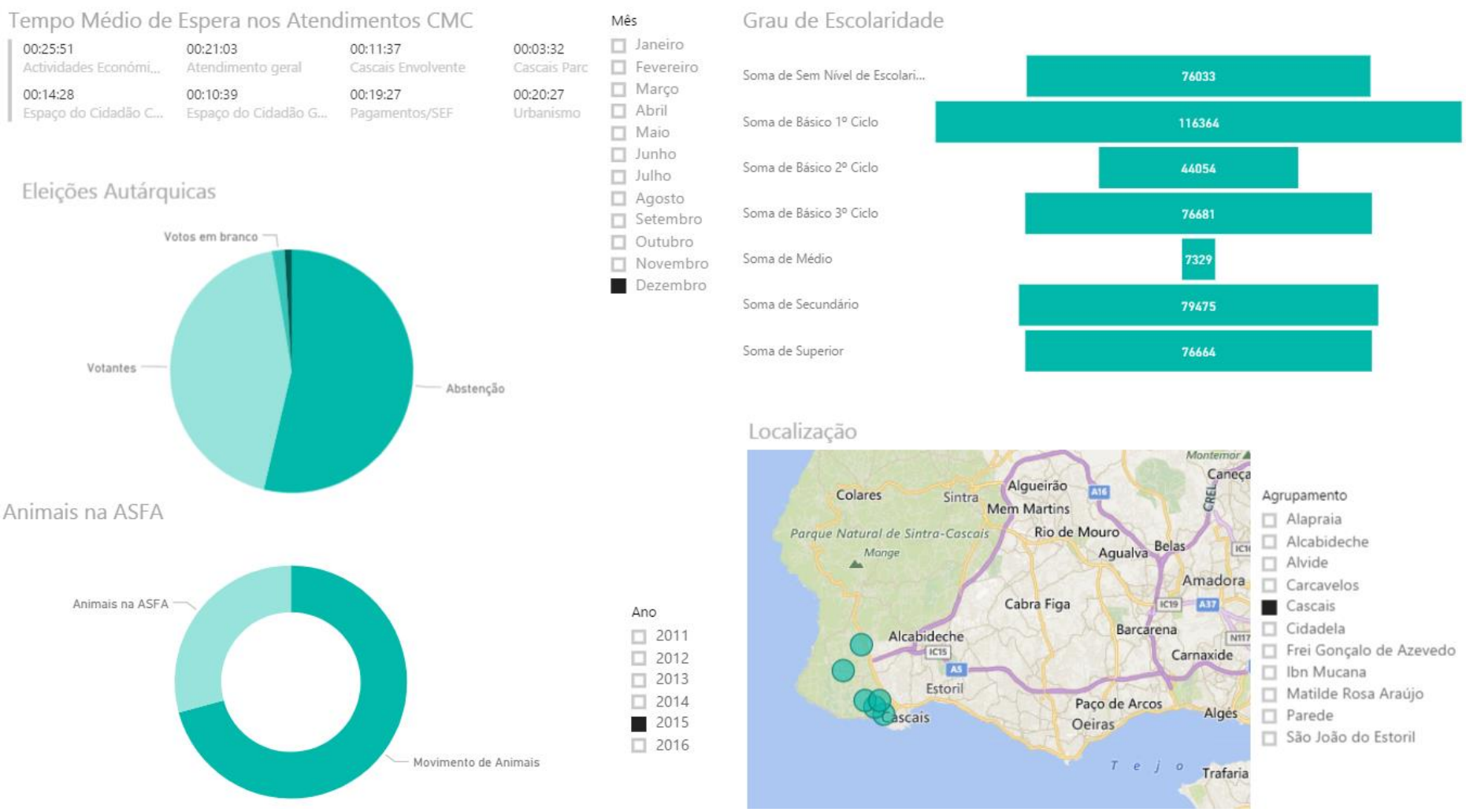

Figure 4.4 – Social (Education and others) Dashboard (the text is in Portuguese due to the target of the artifact)

4.2. APPLICATION CASE

As stated above on the Section 2.3.1, the Cascais Data Portal is constituted by ten themes. In conversation with the project manager of the Cascais Data Portal, it was concluded that it is interesting to have on the portal a dashboard per theme as an introduction. Thereby, when the user enters on the desire theme it will be possible to have a dashboard that resumes the most important indicators (based on the available data) in Cascais.

So, the objective of this application case is to adapt the developed dashboards to the Cascais Data Portal. For that, is necessary to split the three dimensions under study (economy, social and environmental) into the ten themes of the portal.

Since one of the objectives of this project is to be easily adapted to other situations, there was no problem in making this division of indicators. It is possible to see the division made for the themes of Environment, Education, Governance and Security on Figure 4.5 to 4.9.

Despite the indicators already explained, this division implied the addition of others indicators (once it enters in themes with more detail).

On the **Environment** theme, it becomes to be possible to see the location of the waste containers on the different parishes and the relationship between the waste collected that is differentiated or undifferentiated.

Regarding to the **Education** theme, the added filters allow seeing the number of students by grouping, by school and by learning cycle. The annual filter added to the schooling degree, allows seeing the evolution of the schooling degree of the population over the years. Across he added chart related to the high-school, is possible to see the distribution of the high-school students per area of study.

The **Governance** theme, due to the high number of indicators, had to be divided into two dashboards. The added indicators show information about the municipal workers and complete the previous chart about the attendances by showing the monthly number of attendances and their input channel. The second dashboard of this theme is focus on the information about the participatory budget. In this initiative, citizens vote on the project/work they want to see financed. It is possible to verify the evolution of the value of the budget, over the past few years, as well the number of votes and winning areas.

Concerning the **Security** theme, despite the firefighting corporations, it is also possible to verify the location of the security forces.

These dashboards will be available as introduction to the related theme in the Cascais Data after the launch of the portal.

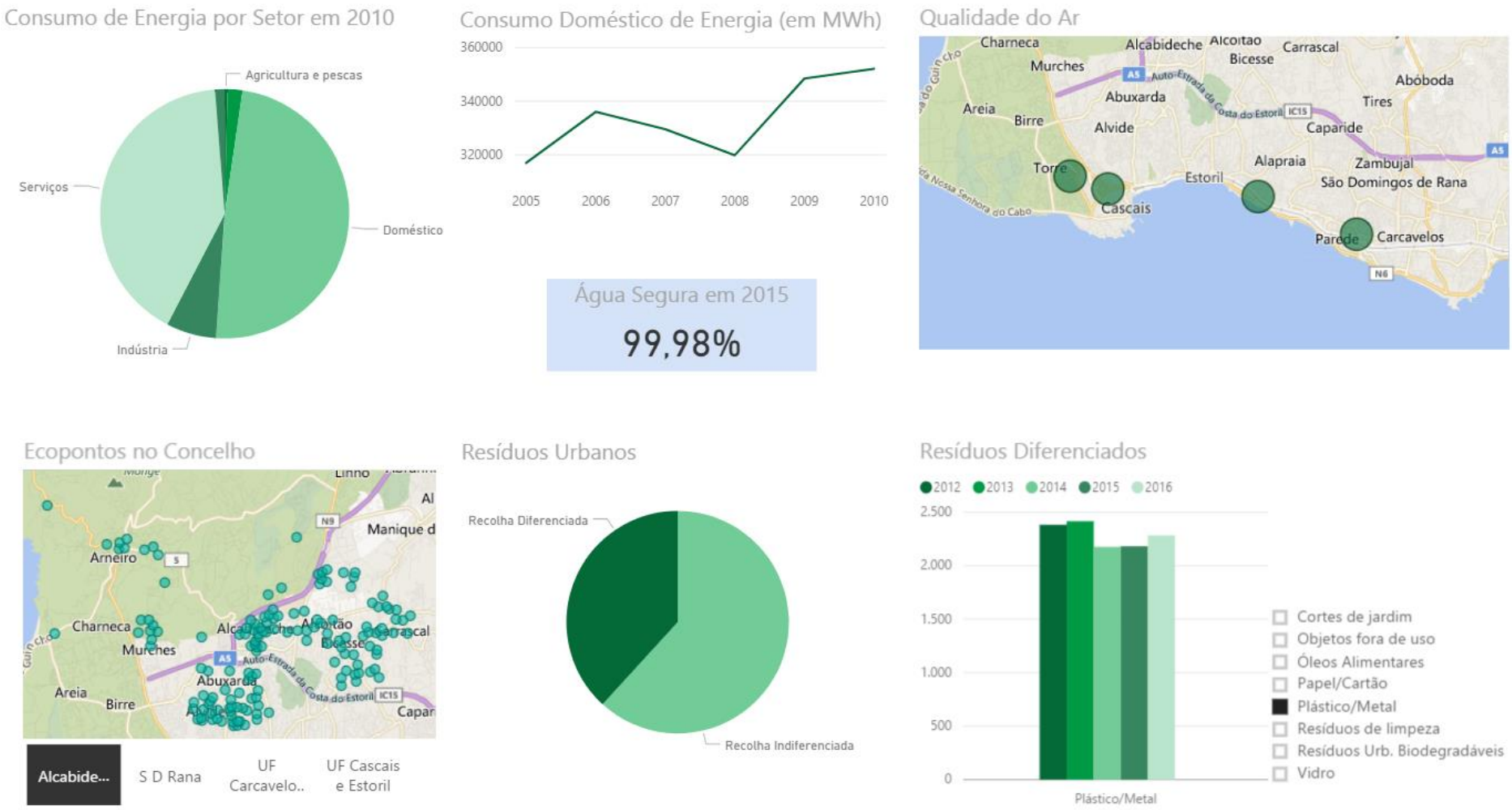

Figure 4.5 – Environment Dashboard of the Application Case (the text is in Portuguese due to the target of the artifact)

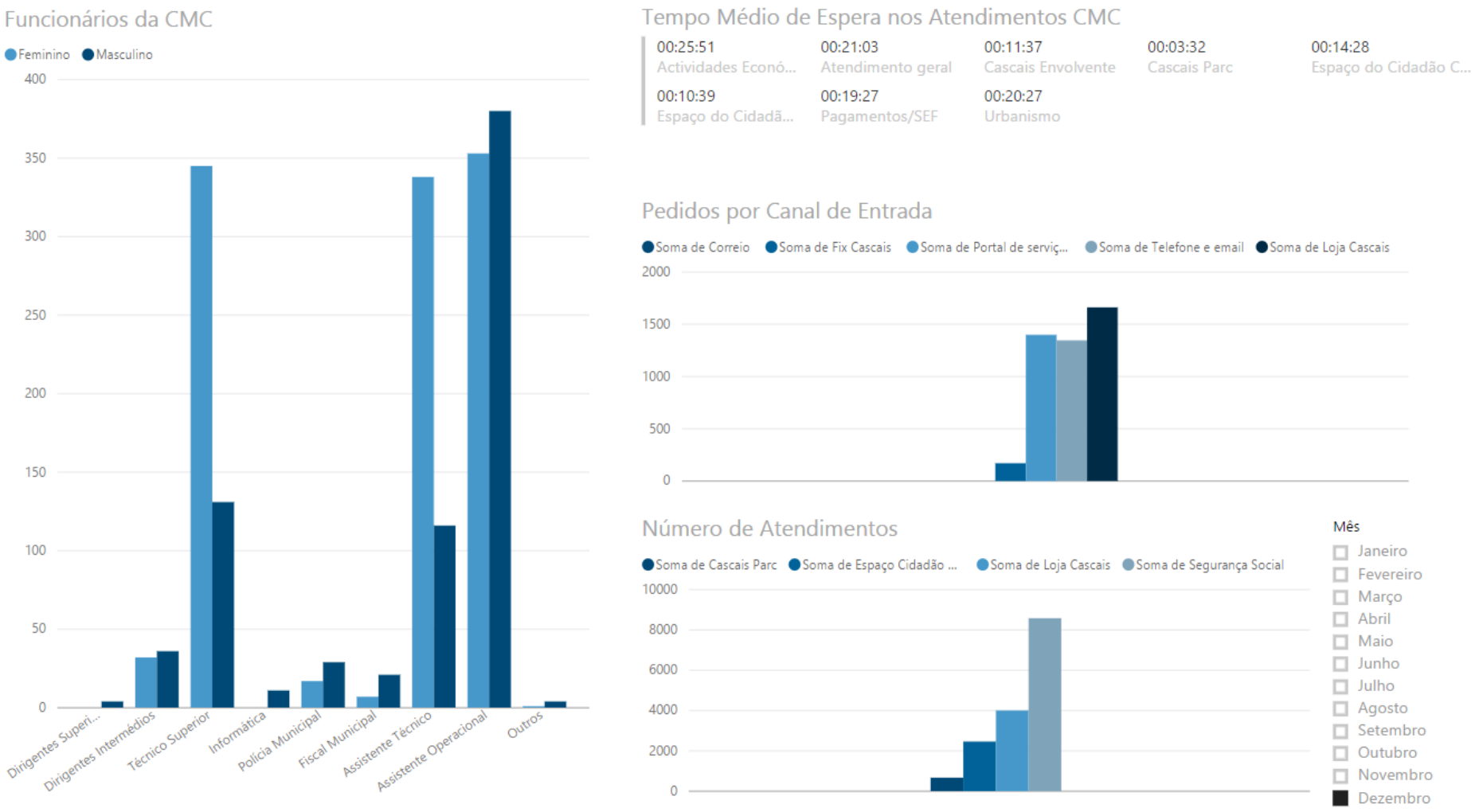

Figure 4.6 – Governance (Attendance and Workers) Dashboard of the Application Case (the text is in Portuguese due to the target of the artifact)

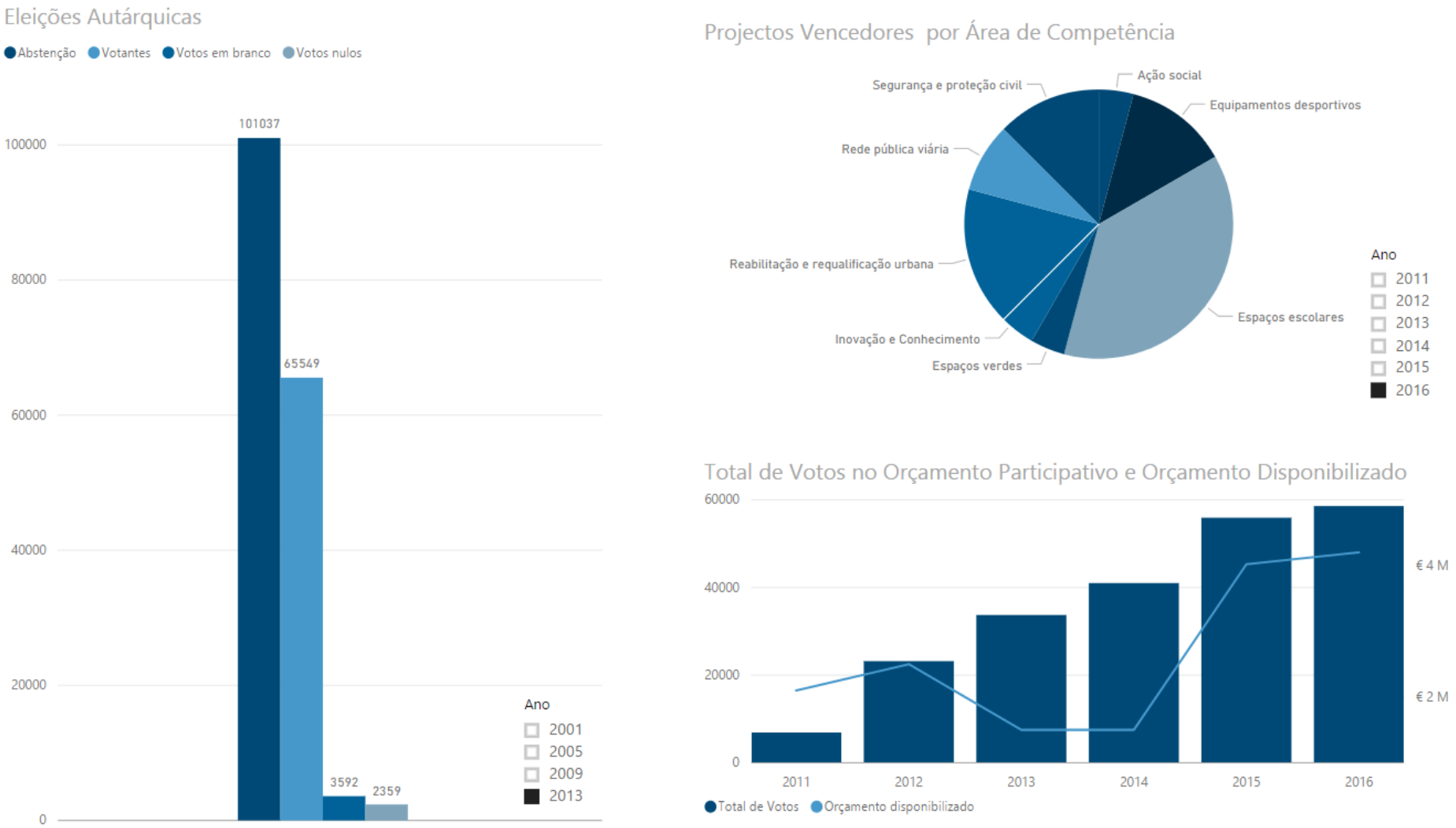

Figure 4.7 - Governance (Elections and Participatory Budget) Dashboard of the Application Case (the text is in Portuguese due to the target of the artifact)

EDUCATION

CASCAIS DATA

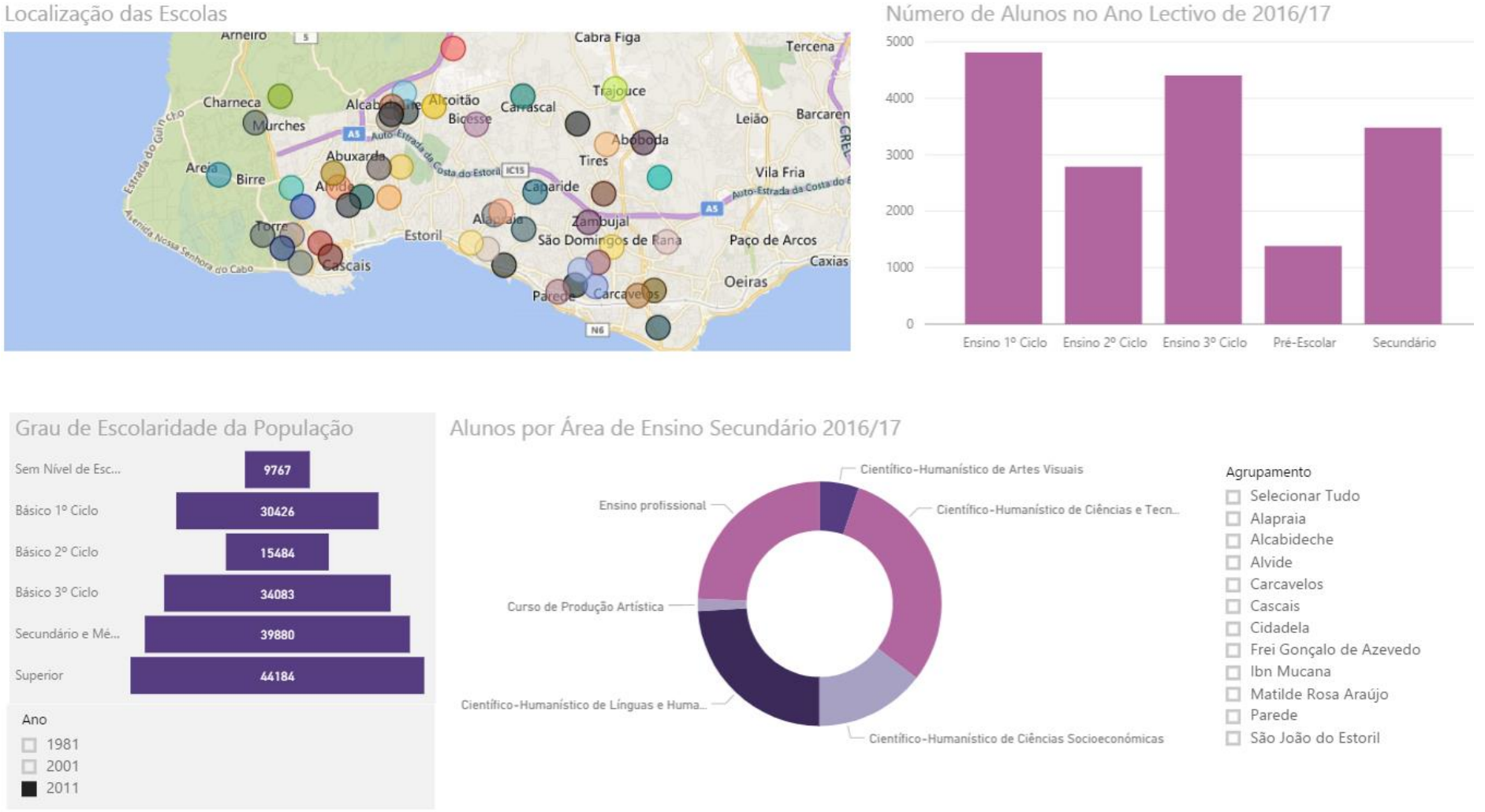

Figure 4.8 - Education Dashboard of the Application Case (the text is in Portuguese due to the target of the artifact)

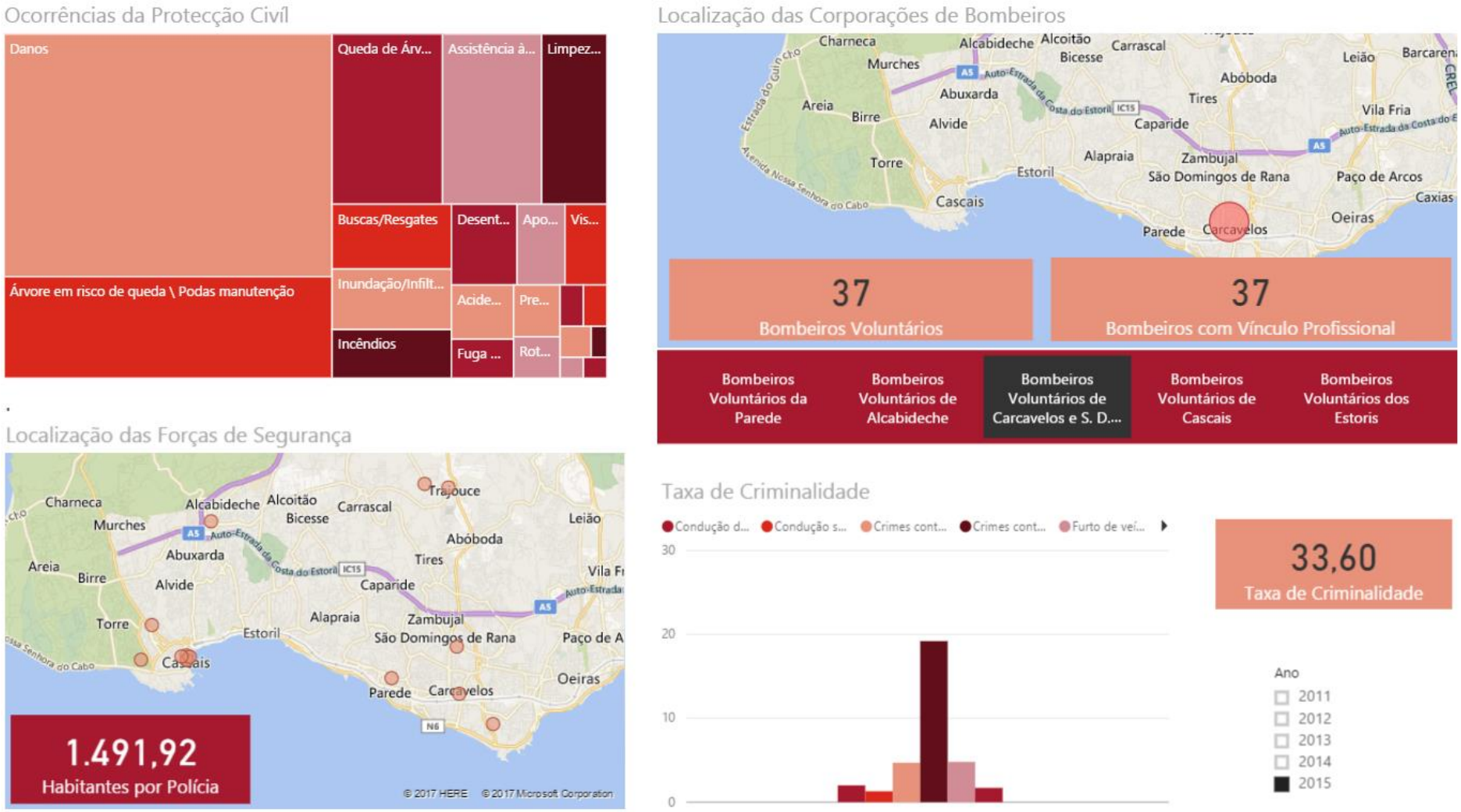

Figure 4.9 - Security Dashboard of the Application Case (the text is in Portuguese due to the target of the artifact)

4.1. EVALUATION OF RESULTS

The referred choice of the indicators allows the release of data that actually can help the inhabitants and the governors to improve the characteristics of the municipality.

The shown indicators (coming from the benchmarking) are considered useful and easy to understand as well as the filters, easily used by anyone. The dashboards are dynamic, with the possibility for the user to perform drill-downs or drill-through and to select desired dates or categories, allowing flexibility and customization

The dashboards can help the inhabitants in their quotidian, to well know their municipality and to access data, improving the transparency between them and the municipality. After published online, the dashboards allow the user to see the data that is feeding that visualization, providing full transparency and allowing the user to have full access to the data.

They allow the communication of information (through the visualizations that have data organized, worked, cleaned and modulated) but also the data that are measuring the smart city performance, like is possible to see in Figure 4.10 and 4.11.

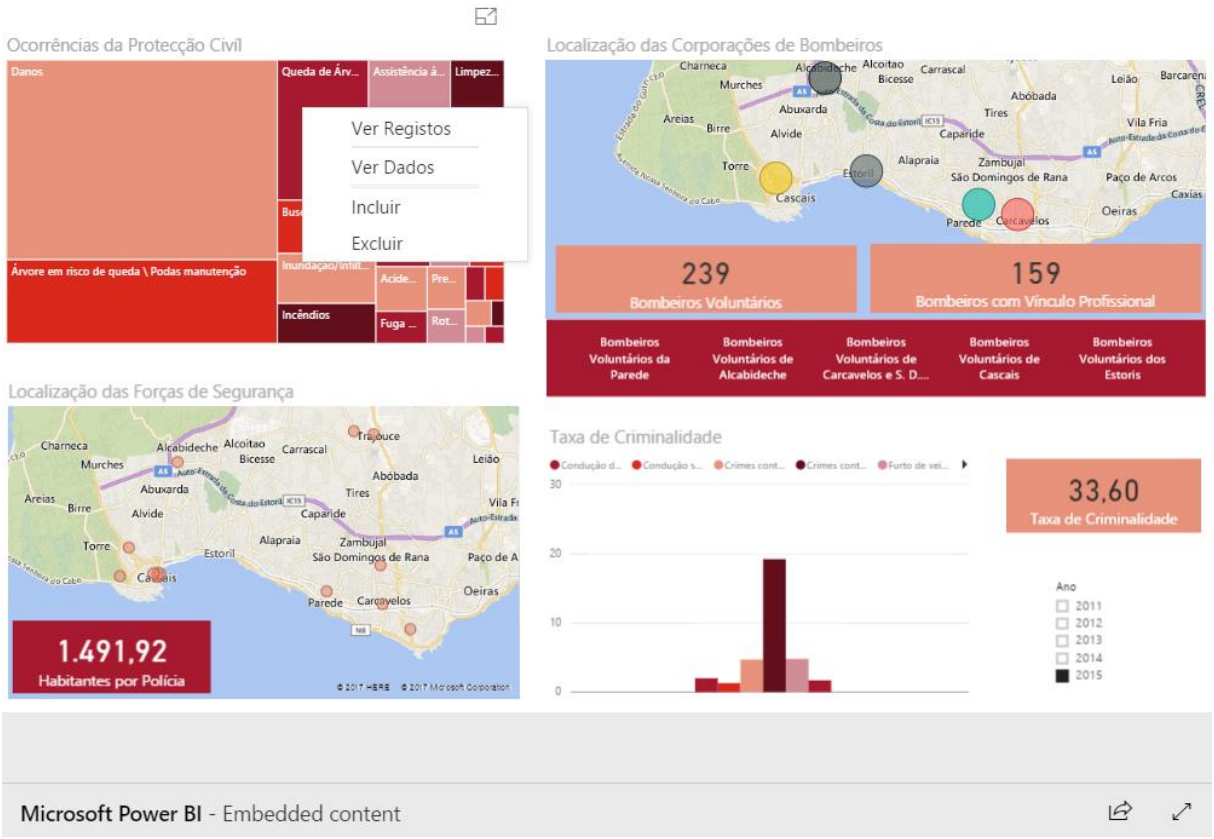

Figure 4.10 – Example of the Security Dashboard published online with the option to see the data behind the visualization (the text is in Portuguese due to the target of the artifact)

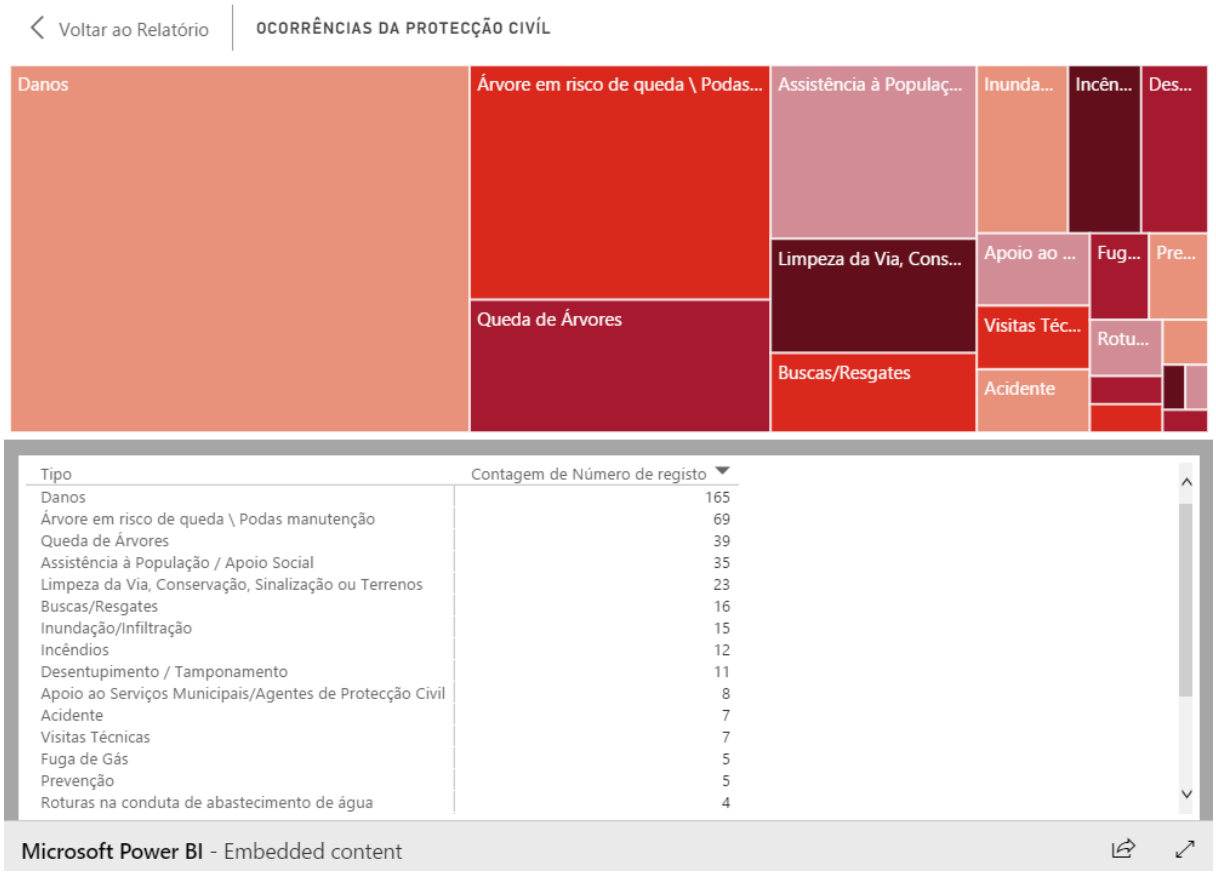

Figure 4.11 – Example of the data possible to see online during the interaction with the dashboard - on this case, to the example of the Civil Protection Occurences chart (the text is in Portuguese due to the target of the artifact)

It is considered that the proposed visualizations are capable of promote public awareness towards what is happening in the municipality, promoting the participation and collaboration by the inhabitants.

They are also capable of improve their quality of life directly (by providing information) and indirectly, alerting the managers to potential failures and aspects to improve.

The chosen indicators reach their purpose of characterize the performance of Cascais, providing an overview of the city in different areas. Therefore, is considered that there is no need of a new iteration of the ongoing cyclic process. This leads to the conclusion of the project, presented in the next chapter.

5. CONCLUSIONS

This project develops a communicative framework that helps the stakeholders of the Cascais smart city to visualize the generated data. Following the steps of the Design and Creation research methodology, dashboards were created as IT artifacts and it is possible to conclude that these city performance dashboards allow a new way of perceiving the municipality by translating it into a rational form of knowledge.

The developed dashboards were used as an intermediary to convert the huge amounts of complex data related to the municipality into information. It is up to the end user to turn this information into knowledge.

Due to the literature review of the project, is possible to conclude that there is evidence of a growing trend towards the presence of the smart city and open data concepts. These terms are increasingly a constant concern in the management of cities.

Based on the benchmarking carried out, it is possible to deduce the lack of dashboards initiatives between cities. Globally, the cities have the data opened but there are no published monitoring, indicators or analysis. Cities are limited to the release of raw data, without creating frameworks that translate this data into information easily interpreted by any stakeholder of the city.

The proposed graphic rules manual is easily applicable to any organization that also uses the Microsoft Power BI tool and an advantage to ensure uniformity throughout the organization. It also can help beginner builders of dashboards who do not have experience in the construction and lack of design notion.

Beyond the graphic standards, it is believed that this whole project is constituted by processes easily adapted to any city and shows how the monitoring of data can be useful in the daily life of the inhabitants.

It is considered that the dashboards make a significant contribution in the monitoring of the data about the municipality of Cascais since they are able to effectively summarize, show accurately, and select relevant information of interest.

On the following figure (Figure 5.1), the main goals of the project were summarized and an analysis of the project's ability to accomplish its initial objectives was carried out reaching the following classification of performance in each objective:

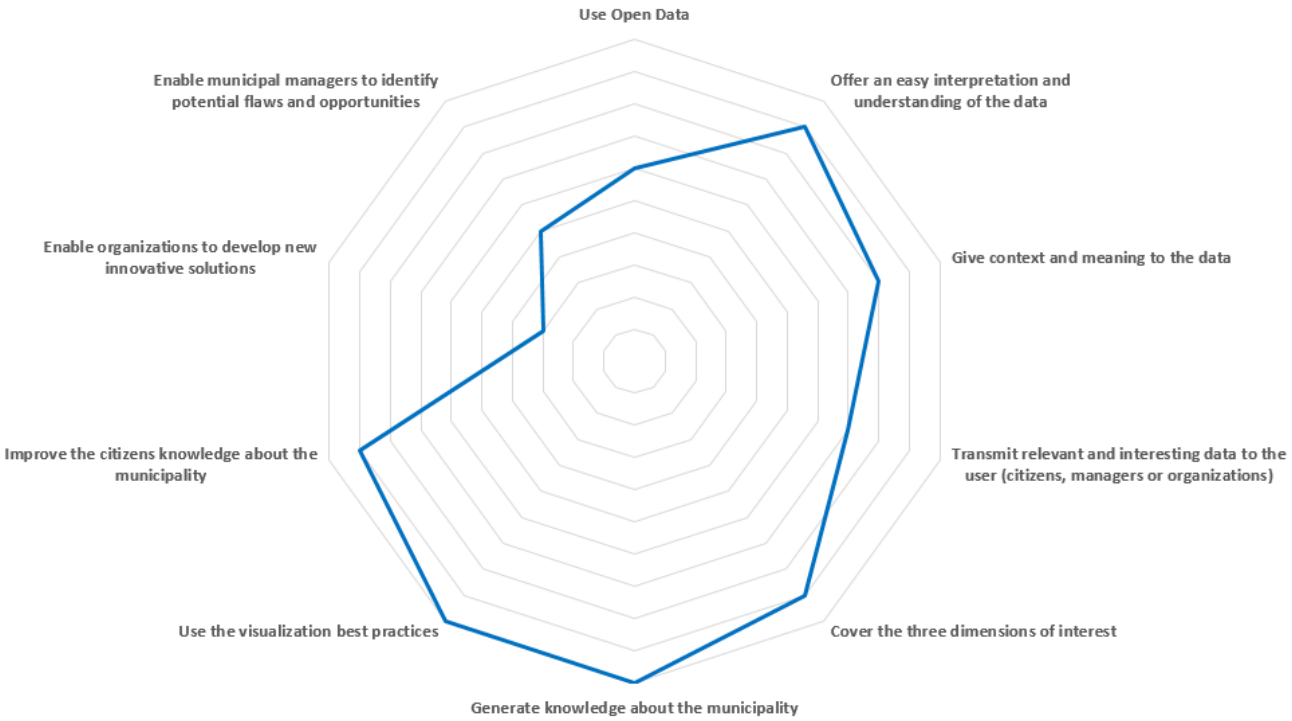

Figure 5.1 – Classification of the project performance in fullfiling its objectives

Analyzing the final result of this project it is possible to infer that the artifacts created are fulfilling their objective with lower incidence in offering insights and allowing the identification of opportunities by managers to improve performance and helping organizations on the development of new solutions. With the exception of the use of open data (that had the referred limitations), it is considered that the project meets all the other goals.

The dashboards created have the potential to inform citizens, improve their knowledge and make them and the city smarter.

5.1. LIMITATIONS OF THE PROJECT

The major limitations of the developed work were:

- The lack of open data available;
- The lack of consistency and quality in data was observed amongst the various departments and services providers of the municipality causing data problem solving and analysis. The data available do not have the same temporal analysis, terms, and features in all the departments of the municipality (which does not allow having the same filter or segment for the entire dashboard);
- The lack of updated data on the municipality (it is difficult to obtain more recent data than the year of 2015).

5.2. FUTURE WORK RECOMMENDATIONS

For future work in this area, some suggestions are left to improve and accomplish the developed dashboards:

- Create links between each graphic and the entirely raw data about the subject that is feeding it;
- Create links to important documents related (for example, if the user selects the Km of bicycle paths, have a map with the paths);
- Define targets and present the results in relation to the desired goal, to provide performance context;
- Present, when possible, real-time data (for example, by integrating the system of the public attendance with the dashboard to know the real waiting time on the public services);
- Try to keep update the data and adapt the presented visualizations to the interest of the audience. The interest can change over time and the indicators should follow them (for example, show the occupation and location of schools at the beginning of the school year);
- Have the various databases of the municipality interconnected in a common layer of relevant indicators, fed by all departments, in order to impose synergies in the municipality and to have the information updated and available to everyone (thus, when necessary to build new dashboards, the information is all concentrated in a single repository and with an easy access);
- Apply the developed framework to other cities with different typologies, dimension and morphology in order to analyze the framework's responsiveness. This analysis can be made following the benchmarking approach presented in this project: benchmarking the different cities that applied the framework and identifying potential improvements to be made to make the framework more adaptable to different situations;
- Update the benchmarking with different cities and new frameworks that may arise or be interesting for a new choice of indicators with different objectives than this project;
- Audit and measure the impact of the dashboards release amongst the municipality and their citizens, concerning the Cascais smart city strategy.

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7. APPENDIX

On this first appendix (Table 7.1) it is possible to see the all the indicators used by each city from the benchmarking: London, Dublin, Los Angeles, Edmonton and Calgary.

CITY	Open Data Portal	INDICATORS								
LONDON	**LONDON DATASTORE** Observations: Each dimension contains a main indicator that appears as a comparison to the homologous period and with an introductory text; When possible, the results have a comparison to the general UK;	**Jobs and Economy**	**Transport**	**Environment**	**Community Safety**	**Health**	**Housing**	**Communities**	**London as a World City**	**GLA Performance**
		Total Workforce Jobs	Lost Customer Hours (Tube)	Recycling	Recorded Crime	Childhood Obesity	Net Additional Dwellings	Population of London	International Visitors	Team London Volunteers
		Unemployment	Number of Journeys on the Network	Household Waste (Kg)	Change in Priority Crimes by Borough	Smoking Quit Rates	GLA Funded Housing Completions	Projected Population by Ethnicity	Number of Visits by Country of Origin	Jobs Crated
		Out of Work Benefit Claimants	Journey Time Reliability	Cost of Waste Management Methods	Confidence in the Police	Well-being	Housing Affordability Ratio	Average Band D Council Tax	Total Spend by International Visitors	London Living Wage Sign-Up
		5+ GCSEc grade A*-C inc English & Maths	Cycle Flows on the TFL Road Network	Carbon Dioxide Emissions by Sector	Police Force Strength	Binge Drinking	Home Repossessions	Londoners by Country of Birth (Top 20, 2014)	International Visitors by City (Top 20)	Reducing Rough Sleeping
		People 25-64 with higher level qualifications	Number of Bicycle Hires	Average Nitrogen Dioxide Levels in London	Crime on the Transport Network	Sports Participation Rate	Monthly Mix-Adjusted Average House Prices	Migrants by Contry (Top 20, 2014/15)	Foreign Born, top 10	Street Trees Planted
		Apprenticeships	Killed and Seriously Injured (KSI)	Average PM2.5 Levels in London	Primary Fires	Life Expectancy at Birth	London Development Database data	Components of Population Change	International Passenger Traffic at Airports	
		GLA Employment Projections	KSI by Road User Type	Reservoir Levels	Vehicle Fires	Mortality Rate from Precentable Causes	Average Private Rent Levels	Talk to neighbours at least once a week		

CITY	Open Data Portal	INDICATORS						
		NEETS	Serious and Severe Disruption on the Roads	Domestic Energy Efficiency Ratings	Arson Incidents	Tooth Extractions for Children		Different backgrounds get on well in local area
								Demographics & Education
DUBLIN	**DUBLIN DASHBOARD: Overview**	Numbers in Unemployed	Current Drive Time	Sound Level	Number of people waiting on trolleys in Hospitals		Average cost of new-build house	Population
		Numbers in Employed	Cameras	Current Air Quality Index for Health	Number of Theft & Related Offences		Average cost of pre-owned house	Females per 1000 Males
		_____	_____	Weather	Number of Public Order & Social Code Offences		Average monthly residential rent	Population Born Outside the State
	DUBLIN DASHBOARD: Indicators	Gross Value Added per Capita at Basic Prices		Waste Produced per Capita	Population Health		Monthly House Unit Completions	Age Profiles
		Survey on Income and Living Conditions		Household Recycling Rate: Dry Recyclables	Crime		Planning Application Statistics	Number of Households
		Numbers by Employment Sector		Household Recycling Rate: Organics	Fire Brigade Call Outs		Available Supply of Housing Land	Household Composition
		Number of Employees by Size of Company		Annual Water Consumption per Capita	Ambulance Call Outs		Annual Contributions to Councils from Developers	Highest Level of Education for Persons Aged 15 and Over
		Overseas Visitors		Water Quality Trends	Number of Persons Injured in Collisions		Average House Prices	Number of Pupils in First Level School
				Schools Awarded the Green Flag	Number of Persons Killed in Collisions		Average monthly Rent Prices for Private	Number of Pupils in Secondary School

CITY	Open Data Portal	INDICATORS							
			Number of Local Agenda Funded Projects			Average monthly Rent Prices by Number of Bedrooms	Number of Special National Schools		
			Typical Traffic Volumes (map)			Number of Inspections of Rented Accomodation	Number of Pupils per Type of Secondary School		
		Economy	**Environment**	**Equity**					
LOS ANGELES	**LA PERFORMANCE DASHBOARD:** each indicator has the target and charts related	New Housing	Imported water Purchases	Air Pollution		Unemployment Rate	Average 311 Call Wait Time	Lane Miles Paved	Trees Trimmed Proactively
		Transit-Oriented New Housing	Locally Sourced Water	Zero-Emissions Vehicles		New Payroll Jobs	Total Homeless Veterans	Street Pothole Repair Turnaround Avg Working Days	Bulky Item Pick Up
		Rent-Burdened Households	Avg Daily Water Use Per Capita	Childhood Asthma		Year Start Reserve Fund Balance	Housing Permits Issued	Sidewalk Miles Repaired % Change	Graffiti Cleaned within 48h
		Average Daily VMT Per Capita	Beach Water Quality	Food Access	**MAYOR'S DASHBOARD:** each indicator has the target		Construction Valuation	MTA Weekday Boardings	Sanitation 2010-15
		Walk, Bike and Transit	Sewer Spills	CalEnviroScreen			DWP Call Wait Time		Water Services Interruptions
		Shared Transportation	Solar Power Capacity	River Public Access			% of Crime Change		Power Outages
		Green Job Growth	Energy Storage Capacity	Residents within 1/2 mile of a park					Solar Interconnection Time
		Green Investment	Average Building Energy Use	Urban Agriculture Sites					Power Poles Replaced and Installed
		Unemployment Rate Gap	Greenhouse Gas Emissions	Walk Score					Water GPCD
		Urban Heat Island Effect	Greenhouse	Traffic Fatalities					

	Economy		Environment	Equity	
			Gas Efficiency		
			Mayors' Climate Action Agenda	Water Use	
			Landfill Diversion Rate	Energy Use	
	New Payroll Jobs	Traffic Collisions	Call Wait Time	Average EMS Response Time	Animal Services Live/Save Rate
	Total Payroll Jobs	Bus On-Time Performance	Total of Delayed Bills	Average Non-EMS Response Time	Girls' Sports Participation
	Total Employment	Miles of Rail Network	Gallons Per Capita Daily	Real Time Public Safety Information	Youth Sports Participation
	New Business Registrations	Miles of Bus Network	Solar Interconnection Time	LAPD Call Processing Time	Lane Miles Paved
	Mean Hourly Wage		Power Outages	LAPD Turnout Time	Sidewalk Miles Repaired
DASHBOARDS BY THEME	Median Household Income		Power Poles Replaced, Installed and Reinforced	LAPD Travel Time	Trees Trimmed Proactively
	Passengers through LAX		Main Breaks	Pollice Officers on Force	Waste Diversion Rate
	Visitors		Miles of Water Main Replaced	Crime Percentage	Graffiti Cleaned within 48h
	Housing Permits Issued		Power System Average Rates	Property Crime Percentage	Website Visitors
	Labor Cost Savings		Water Systems Average Rates	Firefighters on Payroll	Open Data Portal Visitors
	Rent Burdened Households		Water GPCD		
	Population in Poverty				
	Share of Employment Population in Poverty				
	Per Capita Income				

		Economy	Transportation	Environment	Livability	Urban Form	Finance
EDMONTON	**EDMONTON DASHBOARD:** for each indicator, it has a measure description, measure importance, historical data, explanation of performance and useful links. As one of the following options about the result: Meets or Exceeds Target, Near Target, Needs Improvement or Measuring;	Rental Vacancy Rate	Transit Ridership Per Capita	Watershed Contaminant	Fire Rescue Events	New Residential in Mature Areas	Tax-Supported Debt Service Ratio
		Housing Starts	Transit Ridership	Ecological Footprint	Health and Wellness	Well-Designed Attractive City	Municipal Debt
		Housing Sales	Travel Time and Reliability	City Operations Greenhouse Gases	Connected to Community	Access to Amenitioes and Services	Investment Return
		Consumer Price Index	Journey to Work Mode	Community Greenhouse Gases	Safe City	Infrastructure Density	City Asset Sustainability
		Labour Force Participation Rate	Transportation Satisfaction	Solar Electricity	Reported Volunteer Rate	Front Counter Service Level	Credit Rating AA+ Achieved Goal
		Unemployment Rate	Traffic Injury Rate	Lost Grading Inspections	Recreation Facility & Library Attendance	Permit Applications	
		Small & Medium Business	Transit Security	Biosolids Disposal	Crime Severity Index	Actibe Business Licences	
		Non-Residential Permit Value	Dats on Time Performance	Sewer Renewal	City Park Usage	Construction Value	
		Economic Diversity	Vehicle Collision Rate	Sewer Cleaning	Fire First Unit On-Scene		
		GDP	Neighbourhood Snow Blading	Eco Station Users	Leisure Centres Attendance		
			Potholes Filled	Residential Waste Diversion	Major Attractions Attendance		
				Missed Waste Collection Stops	311 Call Response Time		
				Construction Waste Recycled	311 Call Volume		
					Leisure Access Pass		
					Fire Full First Alarm		
					Tree Pruning		
					Pets Rescued or Returned		

		A Prosperous City	A City That Moves	A Healthy & Green City	A City of Inspiring Neighbourhoods	Urban Form
CALGARY	**CITIZEN DASHBOARD**: for each indicator, it is possible to see related measures, service description, the story behind the measure and the importance about it as well the actions undertaken to improve performance	Average Home Price	Accessibility to Transit	River Withdrawals	Person Crime Rate	Single construction Permits Issued
		Retail Sales	Drive Alone to Work	Greenhouse Gas Emissions	Property Crime Rate	Number of Assessment Accounts
		Housing Starts	Pedestrian Collision Rate	Active Adults	Community Belonging	
		Unemployment Rate	Casualty Collision Rate	Urban Canopy Coverage	Access to Daily Needs/Services	
		Construction Permits Issued	Kilometers travelled by sweepers	Kilograms of waste landfilled per person	Number of Emergencies Responded to	
			Trip Request Accommodated	Daily water consumption	Calls responded to by peace officers	
					311 Service Requests Created	

Table 7.1 – Indicators used to measure the performance of each city under analysis

On the next appendix, it is possible to see a table per framework used on the benchmarking: Civic Dashboards, ITU, RFSC, ISO and GCIF. In each table are presented all indicators used by the frameworks. The first one is from Civic Dashboard:

		Economics	Finance	Education	Safety	Health	Housing	People
CIVIC DASHBOARDS	**CITIZEN DASHBOARD:** for each indicator, it is possible to see related measures, metadata about the indicator, as well the behaviour about it over time	Unemployment Rate	Capital Spending	Percent with High School Diploma or Higher	Homicides per 100 000	Percent with Insurance Under 18	Total Housing Units	Percent of US Population
		Percent Living in Poverty	Own Source Revenue	Percent with Bachelors Degree or Higher	Violent Crimes per 100 000	Percent with Insurance 18 to 64	Median Rent	Population Density
		Median Household Income	Debt Service Ratio	Percent Receiving Stem Bachelors Degree or Higher	Property Crimes per 100 000	Percent with Insurance Over 65	Total Building Permits	Dependency Ratio
		Gini Income Distribution		White Students Receiving Bachelors Degree or Higher	Rural Highway Fatalities per 100 000		Occupied Housing Units	Percent Foreign Born
		Number of Business per 100 000		Black Students Receiving Bachelors Degree or Higher	Urban Highway Fatalities per 100 000		Homeowership Rate	Percent Under 18
		Patents per 100 000		Asian Students Receiving Bachelors Degree or Higher	Total Highway Fatalities per 100 000		Single Familiy Building Permits	Percent 65 and Over
		Per Capita GDP					Residential Units per Sq Mile	People per Sq Mile
							Rental Vacancy Rate	
							Multifamily Building Permits	
							Persons per Dwelling Unit	
							Building Permits per 1000 Housing Units	
							Building Permits per 1000 Residents	

Table 7.2 – Indicators used by the Civic Dashboards

On the next table is possible to see the indicators used by the ITU and RFSC frameworks:

ITU INDICATORS			RFSC INDICATORS	
Economy	ICT infrastructure	Internet access in households	Economic dimension	City pair contactability (connectivity)
		Household with a computer		
		Wireless broadband subscriptions		
		Fixed broadband subscriptions		
		Household with a mobile device		Expenditures by the municipality for a transition towards a smart city
	Innovation	R&D expenditure		
		Patents		Employment rate for women and men aged 20-64
		SMEs		
	Employment	Employment rate		Number of organisations with registered environmental management systems according to EMAS and/or ISO 14001 (green growth and circular economy)
		Creative industry employment		
		Tourism industry employment		Share of sustainable food in public canteen and catering
	Trade	e-commerce purchase ratio		
		e-Commerce		
		Electronic and mobile payment		Percentage of projects in partnership with at least 2 others sectors (private, academic, civil society)
		Knowledge-intensive export/import		
		export/import		
	Productivity	Labour productivity		Latest approval or revision date of a master plan with an integrated vision for the city as a whole
		Companies providing online services		
	Public Sector	Open data		

ITU INDICATORS			RFSC INDICATORS	
				Green Public Procurement
				mechanism or plan established for city diagnosis, monitoring and improvement annually
				Satisfaction of local stakeholders with opportunities to participate in local planning and decision-making processes
		e- Public Services adoption		Percentage of lead urban projects managed by a transversal team
				Percentage of your administration's staff that participated in training sessions and/or exchange programmes related to integrated and sustainable urban development
		Health infrastructure	Sporting facilities	
			Availability of smart water meters	
		Water supply	Water Supply loss	Spacial dimention: Basic services proximity
			Water Supply ICT Monitoring	
			Availability of Smart electricity meters	
		Electricity	Electricity system outage frequency	
			Electricity system outrage time	Percentage of trips by private motorised transport
			Electricity supply system management using ICT	
	Physical infrastructure		Public transport network	
		Transport	Road traffic efficiency	Risk reduction and resilience strategy
			Real-time public transport information	
			Share of EVs	Heritage preservation policy
			Traffic monitoring	
		Road infrastructure	Pedestrian infrastructure	Ratio of land consumption to population growth rate
			Public building sustainability	
		Buildings		
		Urban planning	Urban development and spatial planning	
		Public space		Satisfaction with public spaces
Environment			Air pollution	Environment: Number of times the limit of main air pollutants emissions defined by the European directives on air quality is exceeded (PM10, O3, NO2)
		Air quality	Air pollution monitoring system	
			GHG emissions	Greenhouse Gas emissions per capita

ITU INDICATORS		RFSC INDICATORS
Noise	Exposure to noise	
	ICT Noise monitoring	
Biodiversity	Native species monitoring	
	Protected natural area	Climate change adaptation plan
	Compliance with WHO endorsed exposure guidelines	
	Green areas and public spaces	
	Adoption of a consistent planning approval process with respect to EMF (electromagnetic field)	Percentage of Areas designated for nature protection and biodiversity under either international, national or local schemes
	Availability of EMF information	
Environmental quality	Solid waste collection	
	Solid waste treatment	Municipal waste generated per capita
	Recycling of solid waste	
	Quality of drinking water	
	Access to improved water source	
	Water Consumption	
	Wastewater treated	
	Wastewater collection	
Water and sanitation	Household sanitation	Water consumption per capita
	Water saving in households	
	Drainage system management	
	ICT Drainage system monitoring	

		ITU INDICATORS	RFSC INDICATORS
	Energy	Access to Electricity Energy saving in households Renewable energy consumption Electricity consumption per capita Public buildings energy consumption	
Society and culture	Education	Students ICT access Adult literacy School enrollment Higher education ratio e-learning systems	Percentage of early school leavers from education and training
	Health	Electronic health records Sharing of medical resources Life expectancy Maternal mortality Doctors Adoption of telemedicine In-patient hospital beds Health insurance	Green zones and recreational areas proximity (Health)
	Housing	Housing expenditure Informal settlements	Affordability of Housing
	Culture	Connected libraries Cultural infrastructure Cultural resources online	Percentage of municipal budget allocated to cultural and leisure activities
Social and cultural dimension			

		ITU INDICATORS	RFSC INDICATORS
		Percentage of city area related to protected cultural heritage sites.	
		Public participation	
	Social inclusion	Gender income equity	Population at risk of poverty or exclusion
		Opportunities for people with special needs	Gini coefficient of inequality
		Gini coefficient	
		Resilience plans	
	Disaster relief	Natural disaster-related deaths	
		Disaster-related economic losses	
		Emergency Service Response Time	
Safety			
	Emergency		
		Disaster and emergency alert	
		Information security and privacy protection	
	ICT		
		Child Online Protection (COP)	

Table 7.3 – Indicators proposed by ITU-T L.1603 and by the RFSC

On the last table is possible to see the indicators used by ISO and by GCIF:

	ISO INDICATORS
Telecommunication & innovation	17.1 Number of internet connections per 100 000 population
	17.2 Number of cell phone connections per 100 000 population

	GCIF INDICATORS
Technology & Innovation	Number of internet connections per 100,000 population
	Number of new patents per 100,000 per year

	ISO INDICATORS
	17.3 Number of landline phone connections per 100 000 population
Economy	5.1 City's unemployment rate
	5.2 Assessed value of commercial and industrial properties as a percentage of total assessed value of all properties
	5.3 Percentage of city population living in poverty
	5.4 Percentage of persons in full-time employment
	5.5 Youth unemployment rate
	5.6 Number of businesses per 100 000 population
	5.7 Number of new patents per 100 000 population per year
Finance	9.1 Debt service ratio (debt service expenditure as a percentage of a municipality's ownsource revenue)
	9.2 Capital spending as a percentage of total expenditures
	9.3 Own-source revenue as a percentage of total revenue
	9.4 Tax collected as a percentage of tax billed
Governance	11.1 Voter participation in last municipal election (as a percentage of eligible voters)
	11.2 Women as a percentage of total elected to city-level office
	11.3 Percentage of women employed in the city government workforce
	11.4 Number of convictions for corruption and/or bribery by city officials per 100 000 population
	11.5 Citizens' representation: number of local officials elected to office per 100 000 population

	GCIF INDICATORS
	Number of higher education degrees per 100,000
	Number of telephone connections (landlines and cell phones) per 100,000 population
	Number of landline phone connections per 100,000 population
	Number of cell phone connections per 100,000 population
Economy	Percentage of persons in full time employment
	Average household income (US$)
	Annual inflation rate based on average of last 5 years
	Cost of living
	Income distribution (Gini Coefficient)
	Country's GDP (US$)
	Country's GDP per capita (US$)
	City Product per capita (US$)
	City Product as a percentage of Country's GDP
	Total employment
	Employment percentage change based on the last 5 years
	Number of Businesses per 1000 Population
	Annual average unemployment rate
	Commercial/industrial assessment as a percentage of total assessment
Finance	Debt service ratio (debt service expenditure as a percent of a municipality's own-source revenue)
	Tax collected as percentage of tax billed
	Own-source revenue as a percentage of total revenues
	Capital spending as a percentage of total expenditures
Civic Engagement	Voter participation in last municipal election (as a percent of eligible voters)
	Citizen's representation: number of local officials elected to office per 100,000 population
Governance	Percentage of women employed in the city government workforce
	Type of government (e.g. Local, Regional, County)

	ISO INDICATORS
	11.6 Number of registered voters as a percentage of the voting age population
Transportation	18.1 Kilometres of high capacity public transport system per 100 000 population
	18.2 Kilometres of light passenger public transport system per 100 000 population
	18.3 Annual number of public transport trips per capita
	18.4 Number of personal automobiles per capita
	18.5 Percentage of commuters using a travel mode to work other than a personal vehicle
	18.6 Number of two-wheel motorized vehicles per capita
	18.7 Kilometres of bicycle paths and lanes per 100 000 population
	18.8 Transportation fatalities per 100 000 population
	18.9 Commercial air connectivity (number of non-stop commercial air destinations)
Urban planning	19.1 Green area (hectares) per 100 000 population
	19.2 Annual number of trees planted per 100 000 population
	19.3 Areal size of informal settlements as a percentage of city area
	19.4 Jobs/housing ratio
Environment	8.1 Fine particulate matter (PM2.5) concentration
	8.2 Particulate matter (PM10) concentration
	8.3 Greenhouse gas emissions measured in tonnes per capita
	8.4 NO2 (nitrogen dioxide) concentration
	8.5 SO2 (sulphur dioxide) concentration
	8.6 O3 (Ozone) concentration
	8.7 Noise pollution
	8.8 Percentage change in number of native species
Solid waste	16.1 Percentage of city population with regular solid waste collection (residential)
	16.2 Total collected municipal solid waste per capita
	16.3 Percentage of the city's solid waste that is recycled
	16.4 Percentage of the city's solid waste that is disposed of in a sanitary landfill

	GCIF INDICATORS
	Gross operating budget (US$)
	Gross operating budget per capita (US$)
	Gross capital budget (US$)
	Gross capital budget per capita (US$)
Transportation	Km of high capacity public transit system per 100,000 population
	Km of light passenger transit system per 100,000 population
	Number of personal automobiles per capita Transportation fatalities per 100,000 population
	Annual number of public transit trips per capita
	Number of two-wheel motorized vehicles per capita
	Commercial Air Connectivity (number of nonstop commercial air destinations)
	Transportation fatalities per 100,000 population
Urban Planning	Jobs/Housing ratio
	Areal size of informal settlements as a percent of city area
	Green area (hectares) per 100,000 population
Environment	PM10 concentration
	Greenhouse gas emissions measured in tonnes per capita
Geography and Climate	Region
	Climate Type
	Land Area (Square Kilometers)
	Percentage of non-residential area (square kilometers)
	Annual average temperature (Celsius)
	Average annual rain (mm)
	Average annual snowfall (cm)
Solid waste	Percentage of city population with regular solid waste collection

	ISO INDICATORS
	16.5 Percentage of the city's solid waste that is disposed of in an incinerator
	16.6 Percentage of the city's solid waste that is burned openly
	16.7 Percentage of the city's solid waste that is disposed of in an open dump
	16.8 Percentage of the city's solid waste that is disposed of by other means
	16.9 Hazardous Waste Generation per capita (tonnes)
	16.10 Percentage of the city's hazardous waste that is recycled
Water and sanitation	21.1 Percentage of city population with potable water supply service
	21.2 Percentage of city population with sustainable access to an improved water source
	21.3 Percentage of population with access to improved sanitation
	21.4 Total domestic water consumption per capita (litres/day)
	21.5 Total water consumption per capita (litres/day)
	21.6 Average annual hours of water service interruption per household
	21.7 Percentage of water loss (unaccounted for water)
Wastewater	20.1 Percentage of city population served by wastewater collection
	20.2 Percentage of the city's wastewater that has received no treatment
	20.3 Percentage of the city's wastewater receiving primary treatment
	20.4 Percentage of the city's wastewater receiving secondary treatment
	20.5 Percentage of the city's wastewater receiving tertiary treatment
Energy	7.1 Total residential electrical energy use per capita (kWh/year)
	7.2 Percentage of city population with authorized electrical service
	7.3 Energy consumption of public buildings per year (kWh/m²)
	7.4 The percentage of total energy derived from renewable sources, as a share of the city's total energy consumption
	7.5 Total electrical energy use per capita (kWh/year)
	7.6 Average number of electrical interruptions per customer per year
	7.7 Average length of electrical interruptions (in hours)
Education	6.1 Percentage of female school-aged population enrolled in schools
	6.2 Percentage of students completing primary education: survival rate
	6.3 Percentage of students completing secondary education: survival rate

	GCIF INDICATORS
	Percentage of city's solid waste that is recycled
	Percentage of the city's solid waste that is disposed of in an incinerator
	Percentage of the city's solid waste that is burned openly
	Percentage of the city's solid waste that is disposed of in an open dump
	Percentage of the city's solid waste that is disposed of in a sanitary landfill
	Percentage of the city's solid waste that is disposed of by other means
Water	Percentage of city population with potable water supply service
	Domestic water consumption per capita (litres/day)
	Percentage of city population with sustainable access to an improved water source
	Total water consumption per capita (litres/day)
	Percentage of water loss
	Average annual hours of water service interruption per household
Wastewater	Percentage of city population served by wastewater collection
	Percentage of the city's wastewater that has received no treatment
	Percentage of the city's wastewater receiving primary
	Percentage of the city's wastewater receiving secondary treatment
	Percentage of the city's wastewater receiving tertiary treatment
Energy	Percentage of city population with authorized electrical service
	Total residential electrical use per capita (kWh/year)
	Total electrical use per capita (kWh/year)
	The average number of electrical interruptions per customer per year
	Average length of electrical interruptions (in hours)

	ISO INDICATORS
	6.4 Primary education student/teacher ratio
	6.5 Percentage of male school-aged population enrolled in schools
	6.6 Percentage of school-aged population enrolled in schools
	6.7 Number of higher education degrees per 100 000 population
Health	12.1 Average life expectancy
	12.2 Number of in-patient hospital beds per 100 000 population
	12.3 Number of physicians per 100 000 population
	12.4 Under age five mortality per 1 000 live births
	12.5 Number of nursing and midwifery personnel per 100 000 population
	12.6 Number of mental health practitioners per 100 000 population
	12.7 Suicide rate per 100 000 population
Shelter	15.1 Percentage of city population living in slums
	15.2 Number of homeless per 100 000 population
	15.3 Percentage of households that exist without registered legal titles
Recreation	13.1 Square meters of public indoor recreation space per capita
	13.2 Square meters of public outdoor recreation space per capita
Fire and emergency response	10.1 Number of firefighters per 100 000 population
	10.2 Number of fire related deaths per 100 000 population
	10.3 Number of natural disaster related deaths per 100 000 population
	10.4 Number of volunteer and part-time firefighters per 100 000 population
	10.5 Response time for emergency response services from initial call
	10.6 Response time for fire department from initial call
Safety	14.1 Number of police officers per 100 000 population
	14.2 Number of homicides per 100 000 population
	14.3 Crimes against property per 100 000
	14.4 Response time for police department from initial call

	GCIF INDICATORS
Education	Student/teacher ratio
	Percentage of students completing primary and secondary education: survival rate
	Percentage of students completing primary education
	Percentage of students completing secondary education
	Percentage of school-aged population enrolled in schools
	Percentage of male school-aged population enrolled in schools
	Percentage of female school-aged population enrolled in schools
Health	Number of in-patient hospital beds per 100,000 population
	Number of physicians per 100,000 population
	Average life expectancy
	Under age five mortality per 1,000 live births
	Number of nursing and midwifery personnel per 100,000 population
Housing	Total number of households
	Total number of occupied dwelling units (owned & rented)
	Persons per unit
	Dwelling density (per Square Kilometer)
Shelter	Percentage of city population living in slums
	Percentage of households that exist without registered legal titles
	Number of homeless people per 100,000 population
Recreation	Square metres of public indoor recreation space per capita
	Square metres of public outdoor recreation space per capita
	Percentage of jobs in the cultural sector
	Percentage of city population living in poverty
Fire and Emergency Response	Number of firefighters per 100,000 population
	Number of fire related deaths per 100,000 population

	ISO INDICATORS
	14.5 Violent crime rate per 100 000 population

	GCIF INDICATORS
	Response time for fire department from initial call
Safety	Number of police officers per 100,000 population
	Number of homicides per 100,000 population
	Violent crime rate per 100,000 population
People	Total city population
	Population density (per square kilometer)
	Percentage of country's population
	Percentage of population that are children (0-14)
	Percentage of population that are youth (15-24)
	Percentage of population that are adult (25-64)
	Percentage of population that are senior citizens (65+)
	Male to female ratio (# of males per 100 females)
	Annual population change
	Population Dependency Ratio
	Percentage of population that are new immigrants
	Percentage of population that are migrating from elsewhere in the country

Table 7.4 - Indicators proposed by ISO and the GCIF

On the next table is possible to see the Graphic Manual Rules used in this project and to be followed in future dashboards made by Cascais.

	Normas	Descrição	Funções
	Cartão com Valor		
Etiqueta de Dados	Cor: 333333 Mostrar Unidades: Automático Casas Décimais: máximo 2 casas decimais Tamanho: 30	Apresentação de um valor relevante	Destacar valor
Rótulo de Categorias	Inactivo		
Moldagem do Texto	Ativo		
	Série Temporal		
Cabeçalho	Ativo ou inativo conforme necessidade Caso ativo: Cor do tipo de letra: C8C8C8 Fundo: Sem Preenchimento Contorno: Nenhum Tamanho do Texto: 14	Filtos visuais que permitem alguma customização por parte do utilizador. Podem ser categóricos ou temporais.	Alterações Temporais Intervalos Filtros
Entradas de Data	Cor do tipo de letra: 333333 Fundo: Sem Preenchimento Tamanho do Texto: 12		
Controlo de Deslize	Cor: Escolher entre as cores CMC		
Notas	Sem título		
	Tree Map		
Legenda (caso activa)	Posição: Superior Cor: 333333 Tamanho: 10	Apresentam quantidades para uma categoria.	Comparações Hierarquias Parte de um todo Proporção
Cores de Dados	Cor: Escolher entre as cores CMC		
Etiquetas de Dados	Ativo ou inativo conforme necessidade Caso ativo: Cor: FFFFFF Mostrar Unidades: Automático Casas Décimais: máximo 2 casas decimais		
Etiquetas de Categoria	Activa		
	Gráficos Circulares		
Legenda (caso activa)	Posição: Superior Cor: 333333 Tamanho: 10	Ajudam a mostrar proporções e percentagens entre categorias.	Percentagem de um Total Tamanho Contribuição de Diferentes Categorias
Cores de Dados	Cor: Escolher entre as cores CMC		
Etiquetas de Detalhe	Ativo ou inativo conforme necessidade Caso ativo:		

	Normas	Descrição	Funções
	Cor: C8C8C8 Mostrar Unidades: Automático Casas Décimais: máximo 2 casas decimais Tamanho: 9		
	Gráficos de Barras e Linhas		
Legenda (caso activa)	Posição: Superior Cor: 333333 Tamanho: 10	Mostram valores e fazem comparações entre categorias.	Ranking de Items Comparações Padrões Dados ao longo do tempo
Eixo X	Cor: C8C8C8		
Eixo Y	Posição: Esquerda Cor: C8C8C8 Mostrar Unidades: Automático Título: Inativo Casas Décimais: máximo 2 casas decimais		
Cores de Dados	Cor: Escolher entre as cores CMC Ativo ou inativo conforme necessidade		
Etiquetas de Dados	Caso ativo: Cor: FFFFFF Mostrar Unidades: Automático Casas Décimais: máximo 2 casas decimais Orientação: Horizontal Posição: Base Inferior Tamanho: 9		
	Gráficos de Dispersão		
Legenda (caso activa)	Posição: Superior Cor: 333333 Tamanho: 10	Usa o referencial Cartesiano para mostrar como é que as variáveis se distribuem ao longo dos eixos.	Correlações Comparações Proporção Padrões Dados ao longo do tempo
Eixo X	Cor do título: C8C8C8		
Eixo Y	Posição: Esquerda Cor: C8C8C8 Mostrar Unidades: Automático Casas Décimais: máximo 2 casas decimais		
Cores de Dados	Cor: Escolher entre as cores CMC Ativo ou inativo conforme necessidade		
Etiquetas de Categorias	Caso ativo: Cor: C8C8C8 Tamanho: 9		
Limite de Cor	Inactivo		
	Mapas		
Cores de Dados	Cor: Escolher entre as cores CMC	Dão aos valores um contexto geográfico.	Distribuição
Controlos de Mapa	Ampliação ativa		
	Cartão de Linhas Múltiplas		
Etiquetas de	Cor: 333333	Apresentação de	Destacar valor

	Normas	Descrição	Funções
Dados	Tamanho: 9	valores relevantes.	
Etiquetas de Categorias	Cor: C8C8C8 Tamanho: 9		
Cartão	Contorno: Nenhum Mostrar Barra: Ativa Cor da barra: C8C8C8 Espessura: 3 Preenchimento: 8 (adaptável em função do layout do dashboard) Fundo: Sem Preenchimento		
	Tabelas		
Geral	Largura com Redimensionamento: Ativa Tamanho: 9	Usadas para comparer, verificar compoisções e relações entre variáveis e pontos.	Valores individuais
Estilo	Nenhum		
Grelha	Grelha Vertical: Inativa Grelha Horizontal: Ativa Cor da Grelha: Cinza Claro Espessura: 1 Preenchimento: 0		
Cabeçalhos de Coluna	Cor do Contorno: C8C8C8 Espessura: 1 Cor: C8C8C8 Cor de Fundo: Nula Contorno: Superior e Inferior Cor da Letra: 333333		
Valores	Cor de Fundo: Nula Cor Alternativa de Letra: 333333 Cor de Fundo Alternativa: Nula Contorno: Nenhum		
Total	Cor da Letra: 333333 Cor de Fundo: Nula Contorno: Superior apenas		
	Funil		
Etiquetas de Dados	Ativo ou inativo conforme necessidade Caso ativo: Cor: FFFFFF Mostrar Unidades: Automático Casas Décimais: máximo 2 casas decimais Posição: Centro Interior Tamanho: 9	Útil para visualizar um processo que tenha estados. Cada estado representa uma percentagem do total.	Comparações Processo
Cores de Dados	Cor: Escolher entre as cores CMC		
Etiquetas de Taxa de Conversão	Ativo ou inativo conforme necessidade Caso ativo: Cor: C8C8C8 Tamanho: 9		
	Medidor		
Etiquetas de	Ativo ou inativo conforme necessidade	Mostra um valor em	Mostrar

	Normas	Descrição	Funções
Dados	Caso ativo: Cor: C8C8C8 Mostrar Unidades: Automático Casas Décimais: máximo 2 casas decimais Tamanho: 9 Cor: 333333 Mostrar Unidades: Automático Casas Décimais: máximo 2 casas decimais Preenchimento: Escolher entre as cores CMC Destino: Respectiva cor de destaque	comparação à performance desejada.	progresso, distância dos objectivos, situação corrente
Valor de Nota de Aviso			
Cores dos Dados			
KPI			
Indicador	Mostrar Unidades: Automático Casas Décimais: máximo 2 casas decimais	Mostra um valor em comparação à performance desejada.	Mostrar progresso, distância dos objectivos, situação corrente
Eixo de Tendência	Ativo		
Objetivos	Objetivo: Ativa Distância: Ativa		
Codificação de Cores	Cor Correta: 009A44 Cor Neutra: C8C8C8 Cor Incorreta: DA291C		

Table 7.5 - Rules for each visualization of the dashboard

8. ANNEXES

Characteristic	Description
Smart Governance	By Smart Governance we mean joined up within-city and across-city governance, including services and interactions which link and, where relevant, integrate public, private, civil and European Community organizations so the city can function efficiently and effectively as one organism. The main enabling tool to achieve this is ICT (infrastructures, hardware and software), enabled by smart processes and interoperability and fuelled by data. International, national and hinterland links are also important (beyond the city), given that a Smart City could be described as quintessentially a globally networked hub. This entails public, private and civil partnerships and collaboration with different stakeholders working together in pursuing smart objectives at city level. Smart objectives include transparency and open data by using ICT and e-government in participatory decision-making and co-created e-services, for example apps. Smart Governance, as a transversal factor, can also orchestrate and integrate some or all of the other smart characteristics.
Smart Economy	By Smart Economy we mean e-business and e-commerce, increased productivity, ICT-enabled and advanced manufacturing and delivery of services, ICT-enabled innovation, as well as new products, new services and business models. It also establishes smart clusters and eco-systems (e.g. digital business and entrepreneurship). Smart Economy also entails local and global inter-connectedness and international embeddedness with physical and virtual flows of goods, services and knowledge.
Smart Mobility	By Smart Mobility we mean ICT supported and integrated transport and logistics systems. For example, sustainable, safe and interconnected transportation systems can encompass trams, buses, trains, metros, cars, cycles and pedestrians in situations using one or more modes of transport. Smart Mobility prioritizes clean and often non-motorized options. Relevant and real-time information can be accessed by the public in order to save time and improve commuting efficiency, save costs and reduce CO2 emissions, as well as to network transport managers to improve services and provide feedback to citizens. Mobility system users might also provide their own real-time data or contribute to long-term planning.
Smart Environment	By smart environment we include smart energy including renewables, ICTenabled energy grids, metering, pollution control and monitoring, renovation of buildings and amenities, green buildings, green urban planning, as well as resource use efficiency, re-use and resource substitution which serves the above goals. Urban services such as street lighting, waste management, drainage systems, and water resource systems that are monitored to evaluate the system, reduce pollution and improve water quality are also good examples.
Smart People	By Smart People we mean e-skills, working in ICT-enabled working, having access to education and training, human resources and capacity management, within an inclusive society that improves creativity and fosters innovation. As a characteristic, it can also enable people and communities to themselves input, use, manipulate and personalize data, for example through appropriate data analytic tools and dashboards, to make decisions and create products and services.
Smart Living	By Smart Living we mean ICT-enabled life styles, behavior and consumption. Smart Living is also healthy and safe living in a culturally vibrant city with diverse cultural facilities, and incorporates good quality housing and accommodation. Smart Living is also linked to high levels of social cohesion and social capital.

Table 8.1 - Overview of the six smart city characteristics proposed by (Manville et al., 2014)